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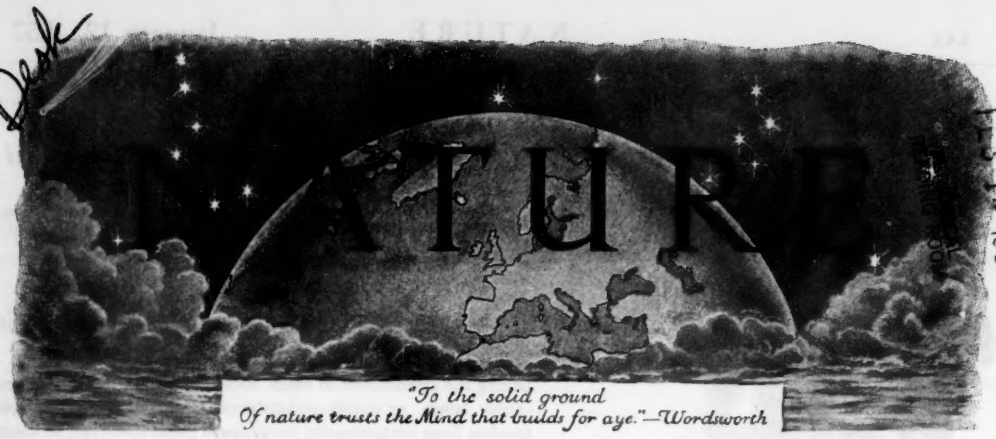

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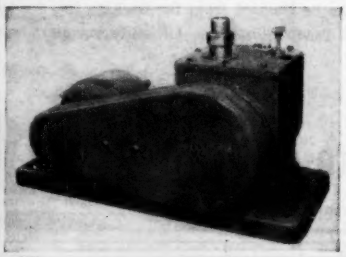

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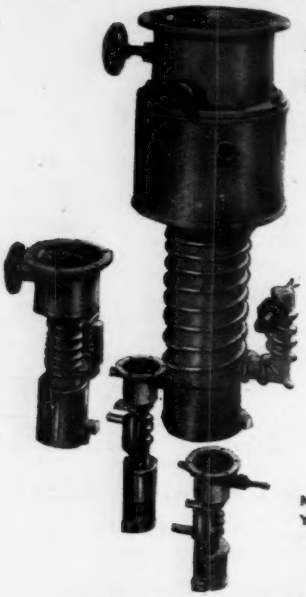

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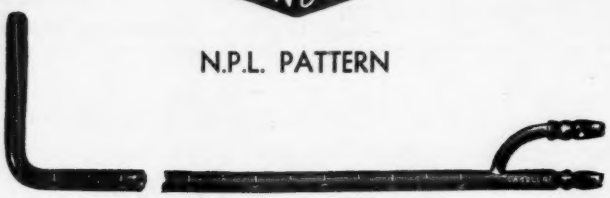

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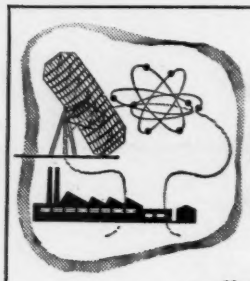

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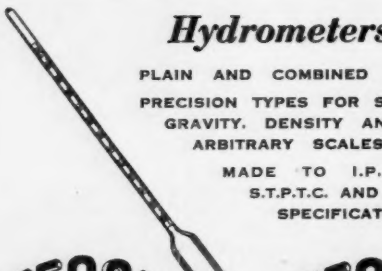

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ACADEMIC FREEDOM AND UNIVERSITY FINANCE

FOR nearly ten years the Committee of Public Accounts has taken strong exception to the device by which Parliamentary grants to the universities in Great Britain are administered through the University Grants Committee, and to the lack of Treasury control over recurrent and non-recurrent grants alike. Similar objection was raised to the absence of statutory authority for the expenditure of the Department of Scientific and Industrial Research, but that objection has been removed by the Department of Scientific and Industrial Research Act of last year. In the Committee's Sixth Report for the Session 1955–56*, the attack is renewed, although the University Grants Committee has now published, with a covering note endorsing most of its recommendations, the report of the Gater Committee on methods used by universities of contracting and of recording and controlling expenditure†. This Committee was appointed by the University Grants Committee in June 1954, under the chairmanship of Sir George Gater, with the terms of reference proposed in a Treasury Minute of December 15, 1953, arising out of the first three reports from the Committee of Public Accounts for the session 1952–53.

The Gater Committee was charged to report on whether the methods of contracting and of recording and controlling expenditure from non-recurrent grants used by universities in Britain are reasonably designed and properly applied to secure effective safeguards against waste, extravagance, or other abuse. It found no evidence in the universities of lack of appreciation of the need for economy; on the contrary, the universities recognize that the present grant system places them under a special obligation to exercise the strictest control of expenditure. Nevertheless, 90–100 per cent of the grants-in-aid from public funds involve some risk of weakening the sense of the financial responsibility, and the Committee urges that it is vital that the universities should never relax their vigilance, and that they should be able to show at any time that they have invariably been concerned to achieve true economy.

The Gater Committee believes that in spite of formidable difficulties since the War, the universities have been successful in their efforts to keep down expenditure, and that any shortcomings have largely been due to causes outside their control. Improvements, however, are possible, and the Committee advances a number of suggestions for systems of administration capable of ensuring prudent and economical expenditure of public funds. The report is welcomed by the University Grants Committee as a valuable statement of the procedures which should be followed, though it has qualified its acceptance of a few minor recommendations. With these qualifications, which are indicated in an annexe, the University Grants Committee considers it of great importance that the universities should in future comply with the recommendations of the report; and in fact some have already welcomed it as affording valuable guidance or commented on how nearly their own practice conforms with that recommended.

This, however, has not satisfied the Committee of Public Accounts. While welcoming the report of the Gater Committee and the action already taken by the University Grants Committee, it points out that the report in itself does nothing to secure greater Parliamentary control over the expenditure of public money. It maintains that, on the evidence supplied, control by the University Grants Committee over the use of non-recurrent grants is not as tight as might reasonably be expected, and, in particular, that grants made in the expectation that they will be spent on major schemes should not be spent at the Committee's discretion on minor schemes. It reiterates its previous recommendation that the Comptroller and Auditor General should at least be given the right of access to the relevant papers and records of the University Grants Committee. If the universities are spending their grants wisely, the Committee argues, they have nothing to fear; nor is it the practice or intention of the Comptroller and Auditor General to raise questions of policy which might conflict in any way with their properly prized academic freedom. Meanwhile, the Public Accounts Committee asserts that it is unable to give Parliament an unqualified assurance that grants have been spent on the purpose for which they were voted and with due regard to the elimination of waste and extravagance. As a Parthian shot, it suggests that the University Grants Committee is not in a position to satisfy itself fully in this matter.

So much for the argument of the Committee of Public Accounts; and Dr. H. V. Wiseman may well remark in an excellent review of the constitutional position of the University Grants Committee, its place in the public finance system and its relations with Parliament and the Treasury, contributed to *Public Administration* last spring, "the outcome of this new phase of a struggle which has now lasted nearly ten years will be awaited with considerable interest". The Committee of Public Accounts appears to have overlooked at least one essential characteristic of the whole system, to which a clue may be found in Prof. S. H. Bear's recent book, "Treasury Control". Prof. Bear does not mention the University Grants Committee, but his stress on the importance in Treasury control of the professional standards of the Civil Service gives more than a hint why the whole system works, and why in practice the control exercised through the University Grants Committee and the universities themselves is in practice a good deal tighter and more efficient than the Committee of Public Accounts is inclined to admit.

Prof. Bear's remarks on the influence of the professional standards of the Civil Service are in line

* Sixth Report from the Committee of Public Accounts, Session 1955–56. Pp. 36. (London: H.M. Stationery Office, 1956.) 1s. 6d. net.

† University Grants Committee. Methods used by Universities of Contracting and of Recording and Controlling Expenditure. Pp. 46. (Cmd. 9.) (London: H.M. Stationery Office, 1956.) 2s. net.

with the comments of other observers as to the bearing of common traditions and outlooks on the working of such a device as the University Grants Committee. Where the Civil Service and the Ministers do not share such an outlook or appreciate from their own experience the point of view and the traditions of the universities, it is liable to break down—if indeed it works at all. Prof. Bear, moreover, refers to the informal sanctions of the corporate life of a college or professional body, and there is a further factor here which the Committee of Public Accounts appears to disregard but which can act as a most powerful check on any tendency to laxity in expenditure by a university body.

The Committee of Public Accounts does not suggest that the universities are not spending their money wisely, though it implies that the universities might under the present system spend unwisely. In seeking for means whereby it may assure Parliament categorically that money is being spent "with due regard to the elimination of waste and extravagance", the Committee has neither faced the difficulty of the criteria for wise spending nor the dangers of superimposing on the present procedure, not simply a new and unpredictable set of interpretations of the term 'wisely', but also methods of control which could well have no less unpredictable effects on the autonomy of the universities, as indeed the Treasury obviously fears. Ignoring the extent to which professional standards and academic practice already provide a powerful and effective means of deciding whether money is being spent wisely, and a sound body of precedent as to what 'wisely' means, the Committee is attacking an ingenious British device for supervising public expenditure in the field of learning, which, if not exportable, has won the admiration of much of the world of learning.

It is not simply that a project on which a university proposes to spend its grant has first to win the approval of the University Grants Committee, which has far more claims for grants than it has money to distribute. The project has itself had to meet the expert criticism of half a dozen committees and the stern cross-fire of professional opinion concerned to uphold university standards and largely quite unprejudiced, if not concerned rather to press the claims of other projects than to defend those of the one in question. Underlying this cross-fire of argument, there is the assumption, abundantly justified in practice, that in such fields as this, control of expenditure is best effected by controllers drawn from the ranks of the controlled: grants for scientific research by scientists, for medical research by medical men, for universities by those versed in academic practice and outlook.

Indeed, to the outsider it may well appear that the Committee of Public Accounts, by its floundering, has largely destroyed its own case. It shows lack of sufficient understanding of the problems and needs of universities to appreciate the advantage to the State itself of the present procedure of allowing universities to control their own expenditure. Nor can any procedure be devised which will give the same safeguard against waste and extravagance as the high integrity and professional standards of members of the university senates and councils.

It is not, however, sufficient merely to await the outcome of the present struggle with the Committee of Public Accounts. With the present mounting scale of public expenditure in the universities already exceeding £30 million a year in recurrent grants and which could easily approach £50 million when the proposed expansion is achieved, others besides the Public Accounts Committee may be concerned at the way in which such sums of public money are expended. Similarly, they may fail to appreciate the peculiar character of universities and the extent to which they require special treatment, from the point of view of the public interest, no less than of their own. British universities cannot, as they have been trenchantly reminded by American and other observers, assume that their present independence will be retained indefinitely unless its meaning and purpose are understood and approved by the community at large. The present procedure is a privilege which will survive so long as it is effective and is approved by those holding political power.

The real lesson of the struggle with the Committee of Public Accounts is the need of greater efforts to interpret to the modern patron of universities—the taxpayer—the purpose of the university, the way it works, its function as a social institution and its place in the State. Clearly there is room for further such exposition in Parliament itself, to which the Parliamentary and Scientific Committee could possibly make a useful contribution. The laymen to be found on the governing bodies of almost all the universities of Britain, however, may be even better placed to undertake this task of public education; and it ranks in importance with the responsibility for scrutinizing expenditure on behalf of the man-in-the-street which, as Sir Eric Ashby has remarked, such laymen can be relied upon to discharge. Nor is this matter unrelated to the expansion projected during the next decade; for unless Parliament as well as the Government has clear ideas of how the universities function and the conditions in which their work is best done, the University Grants Committee is unlikely to be able to prevent the waste of precious resources of man-power and material which will yield no commensurate return, while at the same time vitally important schemes are in abeyance for lack of finance or other resources.

MAN'S HABITAT

Man's Role in Changing the Face of the Earth

Edited by William L. Thomas, Jr., with the collaboration of Carl O. Sauer, Marston Bates and Lewis Mumford. Pp. xxxviii+1193. (Chicago, Ill.: University of Chicago Press; London: Cambridge University Press, 1956. Published for the Wenner-Gren Foundation for Anthropological Research and the National Science Foundation.) 94*s.* net.

IN June 1955 after nearly three years of preliminary organization, seventy scholars of international repute, including fourteen from nine countries outside the United States, met for seven days at Princeton

University, N.J., as the invited guests of the Wenner-Gren Foundation for Anthropological Research. At least fourteen disciplines were represented, and the participants were selected "for their common interest and curiosity about what man has been doing to and with his habitat". Planners and others committed by their professional posts to definite policies or actions were deliberately excluded and every effort was made to secure a free and frank exchange of views, encouraged by a maximum of facilities and creature comforts. The enormous field of studies covered was split into three—Retrospect, Process and Prospect—each forming a group under one of the three co-chairmen, who were respectively geographer Carl O. Sauer (California), zoologist Marston Bates (Michigan) and city land planner Lewis Mumford (Pennsylvania). A primary object of the symposium was to reach a wide public by the publication as a permanent record of the 53 contributed papers with a summary of the discussions.

The result is a volume of more than 1,200 pages, set in double column, weighing nearly 6 lb. and embracing about three-quarters of a million words. It is, in both the English and the French senses, formidable, and can best be regarded as a source book. Most of the papers include a bibliography, in some cases extensive, though the bibliography of one author which extended to 600 typescript pages was not included but has been made separately available. In many cases the papers are convenient summaries of the work for which their individual authors are already well known, but orientated towards the central theme: others have clearly put new thought into the neglected aspect of their own discipline, which deals with its application to human problems. Some have chosen a general approach—Pierre Gourou on tropical cultivation, Lewis Mumford on urbanization, Michael Graham on the harvests of the seas. Others use case studies, and it is interesting to note how European contributors—H. C. Darby, E. Estyn Evans, G. Pfeifer, H. von Wissmann—faced with the complexity of the story of man's occupance of the Old World, prefer to deal with the specific rather than the general.

The summaries of the discussions give a good idea of the interplay of question and answer between experts in disciplines which all too rarely are brought thus into live contact, but a good lively discussion does not always read well in print afterwards. Not unnaturally with such a mass of material the average reader will turn hopefully to the final twenty pages, in which the three co-chairmen make their summary remarks. Each, however, gives up any attempt to summarize even the fields covered, and records personal impressions of the whole conference. In his colloquial speech, which seems to have been taken down verbatim, Carl Sauer comments on a matter of importance which all who have attended international conferences know only too well. It is the growing tendency for his countrymen to abandon the use of simple English, not for a technical jargon which is usually international, but for American slang, extraordinarily difficult of comprehension for the foreigner even when he has a good command of the normal English language.

With such a vast collection of material it would be invidious to mention individual contributions. There are currently two schools of thought regarding man's future adaptation of Nature in the work of physical planning. One is that, to avoid in the future mistakes which have often been made in the past, we should seek humbly and scientifically to study the present position and the stages by which that position has been reached. Only so can we hope to lay a firm foundation for future developments. That is precisely what the symposium set out to do. For example, in the seven papers dealing with modification of biotic communities the past effects of man through fire, agriculture, grazing, forestry, exotic introductions, breeding and plant selection and the spread of organisms are all discussed, as elsewhere are man's work as it affects erosion, land use, soil development. By contrast it is interesting that only seven participants—including Sir Charles Darwin—ventured to contribute papers in Section III—Prospect—dealing with the future. As a whole the symposium gives little support to the present widespread activity and influence of those technological experts who contend that we can safely ignore the present (which is full of examples of man's folly) and the past, and go straight to the future. It is they who would plan the future on a basis of 'land capability'—using classifications based on empirical or subjective judgment.

There is no doubt that this volume is one of great importance. Its very size and monumental character may prevent it from being as widely used as it should be and, although not as expensive by comparison as many recent American publications, cost is another barrier. Is a summary really impossible?

THE RABBIT*

The Rabbit

By Harry V. Thompson and Alastair N. Worden. (New Naturalist Special Volume.) Pp. xii+240+8 plates. (London: William Collins, Sons and Co., Ltd., 1956.) 16*s.* net.

THIS book is the first substantial monograph on a once abundant but, because of its underground life, little-known wild mammal. It begins with a historical and distributional survey. The anatomy of the rabbit, so familiar from dissection in biology classes, is discussed, including the re-ingestion phenomenon or procuration of the soft fæces from the anus for a second digestion in the stomach, a useful device providing food during a natural or enforced stay underground, as well as assuring the sanitation of the burrows, which are kept clean of droppings thereby. That the rabbit 'chews the cud' is mentioned in the Bible; but the significance of the fact was not recognized until the present century. The method of ageing full-grown rabbits by feeling for the apophysial gap (which is fused about the forty-first week of age) at the head of the tibia is described. Our understanding of the elastic reproduction system, still with many puzzling features such as pseudo-pregnancy (ovulation without conceiving) which is more prevalent in the domestic than the wild rabbit, and our knowledge of the pre-natal mortality and subsequent resorption, without abortion, of embryos (up to 64 per cent in wild does), owes much to Prof. Roger Brambell's histological work on 731 pregnant wild does collected in Caernarvonshire. Commercial rabbit trapping with steel-toothed traps catches males first and increases the proportion of females surviving, thus encouraging that which it was intended by farmers to destroy; the trappers were well aware of this—it assured them a good annual crop. The abolition of the steel-

* See also p. 110.—EDITORS.

toothed gin trap is advocated on these and other grounds.

The evidence for a nine–eleven-year cycle of rabbit numbers in Britain was strong, until myxomatosis appeared. The virtual disappearance of the rabbit may benefit the hare because the rabbit is a reservoir for diseases affecting both animals and is, of course, also a grazing competitor. However, the rabbit will not disappear completely; myxomatosis is now enzootic in Australia and France and is appearing sporadically in recovering populations in Britain, where the rabbit's own flea, *Spilopsyllus cuniculi*, has proved the only competent vector. To the benefit of agriculture and forestry we may now expect low numbers for years ahead.

The authors consider that it is doubtful if natural predators are of importance in the control of rabbits except in special circumstances.

This is an important book, bringing as it does right up to date the latest research on both the rabbit and myxomatosis, as well as a full chapter on the legal aspects of rabbit control, as pest and game.

R. M. Lockley

THE STRUCTURE OF TURBULENT SHEAR FLOW

The Structure of Turbulent Shear Flow

By Dr. A. A. Townsend. Pp. xii+315. 8¾ in. × 5½ in. (Cambridge: At the University Press.) 40*s*.

TURBULENCE occurs so frequently in the world around us and is so grossly chaotic in appearance that the layman is inclined to accept it simply as one of the vagaries of Nature. However, turbulence plays such a significant part, not only in Nature, but also in our technological machines, that we are led to seek statistical regularity and predictability within the chaos of turbulence. For the first third of the present century, turbulence research was dominated by concepts of mixing lengths, which, since they were formulated in terms of mean flow properties, were immediately applicable to the solution of practical problems. However, as more information became available about the dynamical behaviour of the turbulence itself, it was found that concepts of mixing lengths were not consistent with the observed behaviour. It thus became necessary to rebuild turbulence theory in conformity with this revised picture of the structure of turbulence.

Turbulence research is carried on in only a few laboratories throughout the world. One of the best-known is the Cavendish Laboratory at Cambridge. There, over the past decade, Dr. A. A. Townsend has been engaged in a systematic investigation of turbulent flows using some of the more advanced techniques currently available in hot-wire anemometry. With Sir Geoffrey Taylor and Dr. G. K. Batchelor, Dr. Townsend has been in the forefront in providing information which undermined the earlier theories of turbulence. In an effort to build a sound theory of turbulence, Dr. Townsend has now written the monograph under notice. He has succeeded admirably in constructing a theory which appears to stand on a firm foundation.

The central framework of the book consists of the experimental observations which have been made by Dr. Townsend and others on the following turbulent flows: isotropic turbulence, homogeneous turbulence undergoing uniform deformation, wakes, jets, flows in pipes and channels, boundary layers with and without pressure gradients and flows between rotating cylinders. Behind these experimental observations, there lurk subtle concepts such as Reynolds's number similarity, self-preserving flows, moving equilibrium and the like that have formed in the minds of the men familiar with the data. Dr. Townsend has done an excellent job of formulating these concepts and showing the part they play in the interpretation of the observations and in the construction of theories consistent with the observations.

From the experimental observations, Dr. Townsend has sought out a picture of the structure of turbulent flows. Earlier, the view had emerged that for isotropic turbulence there exists a range of eddies of intermediate size which contain the major portion of the turbulent energy, and a range of eddies of small size which are responsible for the viscous conversion of turbulent energy to heat. For shear flows, Dr. Townsend adds a range of large eddies of simple structure which are responsible for the large-scale convection. Using this structural picture, he constructs an analytical description of shear turbulence which is convincingly consistent with the experimental observations of both the turbulent and the mean flow fields.

The overall result is a remarkably able discussion of the difficult problem of turbulent shear flow. This monograph will undoubtedly stand as a cornerstone for much of the serious research on shear flows in years to come.

Francis H. Clauser

CHEMISTRY OF HYDROGEN PEROXIDE

Hydrogen Peroxide

By Prof. Walter C. Schumb, Prof. Charles N. Satterfield and Ralph L. Wentworth. (American Chemical Society Monograph Series, No. 128.) Pp. xiii+759. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1955.) 132*s*. net.

SINCE its discovery in 1818 by Thenard, hydrogen peroxide has occupied a unique position in the scheme of chemistry on account of the nature of its chemical bond and its usefulness to the study of catalysis. As the knowledge of its properties increased it was realized that hydrogen peroxide was not an inherently unstable substance and the development of concentrated hydrogen peroxide in Germany during the Second World War as a military propellant demonstrated that the material could be handled on a technical scale and in large quantities. The present book, which covers all aspects of hydrogen peroxide chemistry and technology, is the most exhaustive survey of the existing knowledge on this compound which has yet been written. The authors and their co-workers have during the past decade made a considerable contribution to a wide variety of problems concerned with hydrogen peroxide and they write from a deep and extensive knowledge of technique and experiment with this material. Although reference is made to more than 2,500 published articles the book is not solely a compilation of data—the treatment throughout is selective, thorough, critical, and no aspect of the subject is omitted.

The book begins with the early history and technical development of hydrogen peroxide. This is followed by descriptions of the present-day methods of formation and manufacture from water or oxygen

and from peroxy compounds. Since the technological processes depend on the detailed knowledge of the chemical reactions involved these two aspects of the subject are considered in juxtaposition. A large number of synthetic processes have been considered from time to time and these chapters provide a most illuminating account of the wide variety of reactions involved. Subsequent chapters are devoted to the purification, concentration, and handling, and an extensive, accurate and detailed summary is given of the thermodynamic and electrical properties. The structure and architecture of the molecule and the nature of its solutions have always been intriguing problems to the chemist and the account in chapter 6 is clear, very readable and valuable. The discussion of the chemical properties of hydrogen peroxide which occupies the next three chapters is considered under the broad titles: (*a*) chemical properties, (*b*) decomposition processes, and (*c*) stabilization. In each section completeness has been attained by a certain amount of duplication and overlapping of information. The final three chapters deal with the methods of qualitative and quantitative analysis, the use of hydrogen peroxide including bleaching, oxidation, and as a source of energy, and the preparation and properties of inorganic peroxides and super oxides.

The book can be unreservedly recommended to all interested in hydrogen peroxide, whether their interest be fundamental or technological. Portions of the book will also prove of value to those concerned with biology and medicine, catalytic processes and rocket propulsion.

C. E. H. Bawn

MINERAL WEALTH OF THE INDIAN SUB-CONTINENT

India's Mineral Wealth

A Guide to the Occurrences and Economics of the Useful Minerals of India, Pakistan and Burma. By Dr. J. Coggin Brown and Dr. A. K. Dey. Third edition. Pp. xxiv+761+8 plates+12 maps. (London: Oxford University Press, 1955.) 50*s*. net.

THE last edition of this work was published in 1936 and has for long been out of print. This greatly enlarged third edition comes at an opportune time, when India, Pakistan and Burma are concerned with elaborate plans for industrial development. Since modern industry depends so much on the availability of minerals, an up-to-date appraisal of the mineral wealth of the three countries will prove of value to their Governments, to their industrialists and to their geologists, mining engineers and metallurgists engaged in exploring and exploiting those minerals.

When the first two editions were published, present-day India, Pakistan and Burma formed part of the Indian Empire; and though the original title has been retained, the work is now concerned with the mineral wealth of three independent States, and not with present-day India alone as the title might suggest.

Since the Geological Survey of India was started just over a century ago, a great deal of information has been accumulated and recorded in the various publications of that department, and in the transactions of learned societies. Few of those concerned with mineral development have the opportunity to search these publications for the information they require. But with this new edition available they can obtain up-to-date information about almost any mineral found in the three countries. This includes a summary of the geology and origin of each mineral, an account of the industry and its economics, statistics of production, analytical data, and maps showing the distribution and geological provenance of the more important minerals. In addition to minerals proper, similar information is also given regarding mineral fuels, building materials, soils and water supplies, the last two having been added to this edition because of the importance of increasing food production to keep pace with a growing population. There is also a valuable bibliography covering every substance dealt with.

No country is completely self-sufficient in minerals. India has adequate supplies of bauxite, coal, iron ore, ilmenite, magnesite, manganese ore, mica, monazite, chromite and gold, but is deficient in ores of copper, lead, silver, tin, zinc and tungsten, and in petroleum and sulphur. Pakistan is poorly provided with most minerals except oil and natural gas, salt, gypsum, chromite and limestone, and at the time of partition little more than 3 per cent of the mineral production of undivided India came from what is now Pakistan. Burma, however, has good supplies of tin, tungsten, lead, zinc and petroleum. Therefore, if the three countries are considered together, as is done in this book, we have a region that is fairly well supplied with the major minerals required in modern industry.

The total value of minerals produced in India has risen enormously during the past few decades. In 1928 the total annual value of minerals raised in India, Pakistan and Burma amounted to about £24 million. To-day the figure for India alone must amount to more than £90 million. Though much of this increase is due to increase in the actual value per unit, there has also been a steady increase in the volume of many of the minerals produced, and new developments during the past few years suggest that the rate of increase will become accelerated. These new developments, as the authors point out, include the discovery of an extensive lignite field in Madras State (where no coal occurs), new oilfields and a great gasfield in West Pakistan, the revival of lead and zinc ore mining in Rajasthan (begun in the fourteenth century but abandoned at the beginning of the last century), the proof of the continuation in depth (without loss of quality) of the manganese ores of Madhya Pradesh, the discovery of emeralds in Rajasthan, the manufacture of ammonium sulphate on a great scale in Bihar (from Indian gypsum), the installation of several oil refineries (for which at present most of the crude oil has to be imported), the processing of uranium and thorium-bearing rare-earth minerals in Travancore, and the proposed great increase in the production of pig iron, steel and ferro-alloys. Perhaps the most important present requirement is an increase in the production of oil, and it is significant that the Government of India is prepared to spend something like £25 million during the next five years on exploration for oil in areas outside those covered by private oil companies.

The book is an up-to-date and accurate survey of the mineral wealth of India, Pakistan and Burma, and it should be in the hands of all those concerned with the development and utilization of that wealth. If criticism is offered, it is with regard to the format of the book, which has now swelled to a thickness out of proportion to its other dimensions.

W. D. West

Design of Reinforced Concrete

By Dr. Boris W. Boguslavsky. Pp. viii+428. (New York and London: The Macmillan Company, 1956.) 42*s*.

THIS book has been written mainly for the young designer of reinforced concrete and would be very suitable for technical college evening classes were it not based wholly on American practice. This very seriously detracts from its value to the British student, who finds changing methods and notation a very serious handicap with reinforced concrete design work, and who, moreover, requires to be trained in British practice for his various examinations.

The simplicity of approach is rather overdone for the university undergraduate in Britain, who normally has a good grounding in strength of materials and in theory of structures before starting on design work, and would be able to work more easily from his basic knowledge than from some of the elaborate formulæ evolved. That, combined with the purely American practical angle, would weigh heavily against its recommendation as a text-book for British university students, although no doubt it would be very suitable for their opposite numbers in the United States, whose approach is rather different, and who naturally wish to be familiar with the regulations of the American Concrete Institute.

Starting with elementary theory of structures, and progressing, with an eye to practice, through the design of simple reinforced concrete elements, the student is led to the design of a reinforced concrete building by easy stages, with a small amount of work on arches and pre-stressed beams *en route*. There are many detailed illustrative examples throughout, most of which are simple and easy to follow, in the light of American methods; but prestressed beam design, being wholly on non-bonded post-tensioned cases, would be very misleading to British students. On the whole, this is a book for students in the United States, or for the already knowledgeable in Britain who wish for a glimpse of American practice.

J. W. H. King

Androgens

Biochemistry, Physiology, and Clinical Significance. By Prof. Ralph I. Dorfman and Prof. Reginald A. Shipley. Pp. xvii+590. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 108*s*. net.

IN the foreword to this book, Warren O. Nelson rightly directs attention to the far-reaching significance of androgenic function; so vast has the literature on this subject become (as, indeed, on many other endocrine subjects) that the need for a truly comprehensive monograph has long been felt by a wide circle of clinicians, biochemists, biologists and others. This is the first and only publication devoted specifically to the androgens, and it has been conceived on a large scale; a glance through the contents, which, in fairly small print, alone covers nine pages, is sufficient to carry conviction on this point.

After a brief introduction, which also sketches the historical background, the second part deals with biochemistry, including an extensive section on the metabolism of androgens. Part 3 is devoted to the physiological effects of androgens, and Part 4 to clinical aspects. Finally, there are important appendixes. The first of these gives the names and structural formulæ of 225 compounds of significance to this subject; each is numbered, and at each mention in the text the number is given—a most valuable reference device. The remaining appendixes are concerned with the techniques of androgen determination, chemically and biologically.

Obviously, workers in many disciplines may find valuable information in this book, which has a good index, extensive bibliographies at the end of each chapter, and large numbers of tables and figures. Though perhaps mainly a work of reference, the clinical section is certainly very readable, the others—inevitably—perhaps slightly less so.

G. I. M. Swyer

Ceramics for the Archæologist

By Anna O. Shepard. (Publication 609.) Pp. xii+414. (Washington, D.C.: Carnegie Institution of Washington, 1956.) Paper bound, 6.75 dollars; Cloth bound, 7.75 dollars.

FOR many a year, archæologists have been trying to make common ground with scientists versed in the special techniques of importance for analysis of the results of work in the field. Here is an excellent example of such co-operative thought applied to ceramics. But Miss Shepard has achieved more than that. She has welded, so to say, the 'know-how' with just the requisite amount of æsthetic theory (for example, problems of proportion, shape, tangency relations and so forth) to lift the subject well out of the range of mere 'doctoring' and *ad hoc* solutions.

It is possible, however, that the physicist and chemist would wish to refine their methods a little further, in which case some reference to the microscopical processes and instrumentation associated with the names of Schneiderhöhn and von Federov would have been helpful; these developments being particularly well suited (within their own limitations) for the examination of opaque sections, and even of curved fragments, without any trace of destructive testing. Given adequate illumination, classical optics, in modern guise, could render still further assistance to workers in archæological enterprise.

F. I. G. Rawlins

The Elementary Particles of Nature

Prepared by Dr. D. K. Butt, Dr. E. G. Michaelis, Dr. G. L. Miller and Dr. P. T. Trent. Pp. 19. (London: Science Information Service, 1956.)

THE purpose of the very useful set of notes contained in this pamphlet is to present a simple but informed account of the now numerous particles, including the unstable forms of matter, the mesons and hyperons, which are studied extensively to-day and which constitute the basis of nuclear physics. The notes have been prepared by four young and active workers in this field, but they have taken care to avoid too much detail and technicalities and to express the main agreed results in a form which teachers in colleges and schools in particular will find most valuable. In 1930 the number of fundamental particles required to describe matter was no more than two, the proton and the electron, but following the discovery of the neutron in 1932 and the μ-meson in 1935 the number of 'elementary particles' has continued to increase and no less than twenty-four are listed in the pamphlet. These do not include the anti-neutron the existence of which was verified too recently to receive mention. Brief reference is made, however, to the anti-proton, which was identified with certainty towards the end of 1955.

S. Weintroub

COMMUNICATION IN SWARM-BEES SEARCHING FOR A NEW HOME*

By Dr. M. LINDAUER
Zoological Institute, University of Munich

WHEN animals establish a new dwelling place, most of them meet many different kinds of problems. In general, the following three requirements must be met by the new home: (1) it must afford protection against all kinds of weather conditions; (2) it must be well situated as a headquarters from which to obtain nourishment; (3) it must afford a rendezvous for courtship and a nursery for the offspring.

In the case of animals, such as the honeybees, which live a social life, the dwelling place takes on an additional significance: here is the meeting place where many thousands of bees gather again after having roamed about during the day. Here is the place where every bee, day in and day out, receives information. In other words, here is the place where all functions of those 50,000–80,000 individuals become integrated into a community life.

In such a situation it is understandable that the seeking out of a nesting site takes on a special importance. The establishment of a new dwelling place of bees is always accompanied by swarming. As is well known, the mother colony separates itself in such a way that one half remains behind in the old home with the newly raised queen and the old queen moves out with the other half of the colony. This is the swarm which forms a cluster in the neighbourhood of the mother hive.

If the swarm is not caught (as is usual in beekeeping) it must provide a new home for itself. So after the bees have formed the swarm cluster some scouting bees fly off in order to seek a suitable nesting place. These 'messengers' fly off in all directions, and when they have discovered a suitable building place they fly back to the swarm and announce the spot to their companions. They do this in the same manner as successful forager bees; that is to say, by the well-known bee dance, they give information concerning the distance and the direction of the newly found nesting site.

If the scouting bees are marked and a record kept of the messages given by their dances, then it will be seen that the bees announce several different nesting sites at the same time. For example, it can happen that some of the scouting bees indicate a spot which is situated 800 m. to the north where a hole in a tree has been discovered; others indicate a dwelling place 2 km. to the south, where perhaps a hole in the ground has been observed; a third group apparently has inspected a hollow in an old wall. This conclusion is drawn from the fact that the dancing bees are covered with red brickdust or with street dust, which is never the case with dancing forager bees. Furthermore, by examining the dancing bees, I could sometimes discover the location of the nesting site long before the swarm moved in. In one case, it appeared that the bees found a nesting place in an empty chimney at 300 m. distance: their dancers were completely covered with soot, and when I caught some in the swarm cluster they smelt very like chimney sweeps.

In this way, ten to twenty different locations can be communicated to the swarm, and so we arrive at the question: How do the bees come to an agreement as to which of the many possibilities they should choose? The swarm cannot break itself up. It must move in a group with its queen into one of the dwelling places offered.

That agreement actually takes place can be seen if the dancers in the cluster are carefully watched. At first the scout bees indicate different directions and distances through their bee dances; then, step by step, after a few hours or sometimes after a few days, the dances become more harmonious; in other words, a definite direction is chosen, while the other dances disappear. Only when an agreement is reached in such a way does the swarm fly off and move into its new home.

Fig. 1 demonstrates an example of how a swarm comes to such an agreement. Each arrow represents a scouting bee which was marked during the dance in the swarm; direction and length of the arrow represent to scale the location of the goal. In all, twenty-seven nesting places were discovered by the scouting bees of this 'Eckschwarm'. It appeared first of all as if the nesting site 1,000 m. away to the north would be preferred. But on the fourth day interest became concentrated more and more on the place 300 m. to the south-east, and to that place on the fifth day the swarm flew off. We were able to follow the swarm during the trip and we saw the bees move into a hole in an old wall 300 m. to the south-east.

But agreement about one of the nesting places offered does not always take place so quickly and harmoniously as this. It can happen that the interest of the scout bees becomes concentrated upon two nesting places at the same time. In this case it is very difficult to force one of the two groups to yield. Fig. 2 demonstrates such a case.

Finally, however, agreement normally must take place before the swarm moves. Up to now it has happened only twice in nineteen experiments that agreement was not reached, and this led almost to a catastrophe for the swarm. In the case of the 'Moosacher Schwarm', two equal groups of scout bees were formed, and as neither of them yielded, the swarm flew off and—I could scarcely believe my eyes—it tried to separate itself into two groups: one group of scout bees wished to lead the swarm to a nesting site in the north-west, the other group to the north-east, each to its 'own' nesting place. Since such a division into two groups was naturally not possible, a battle took place in the air between the two groups until, after half an hour, the swarm finally flew back to the old headquarters. Now the north-east group gave up, and so in this case also an agreement was eventually reached over the new home to the north-west.

* Substance of a paper read before Section D (Zoology) at the Sheffield meeting of the British Association.

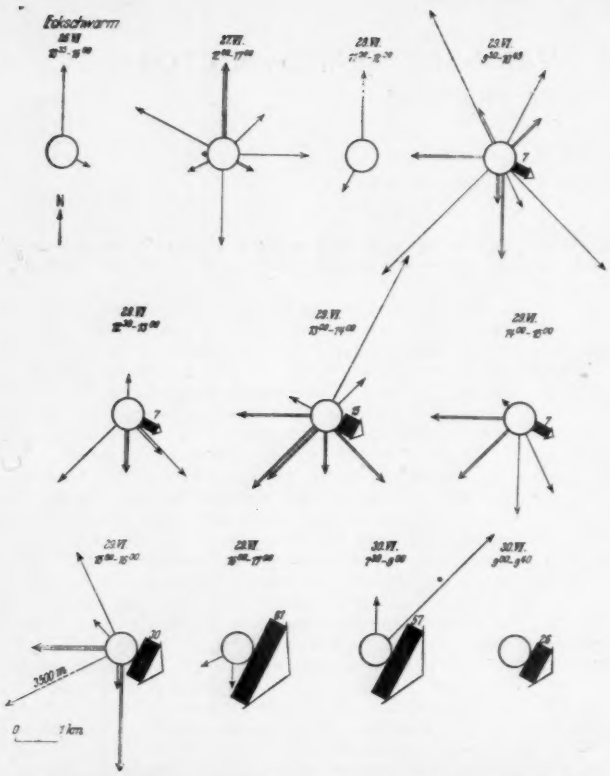

Fig. 1. The scout-bees were marked during the dance. Each arrow represents the announcement of one such bee. Length and direction of the arrow correspond to the location of the newly found nesting-place. For the nesting-place 300 m. south-east, in favour of which the decision was made, instead of separate arrows the number of dancing scout-bees is directly indicated. From *Z. vergl. Physiol.*, **37**, 263ff., Ab. 3 and 4 (Springer-Verlag, 1955).

Much more tragic was the fate of the 'Busch-Schwarm': since after fourteen days no agreement was reached, the scouting bees gave up their dances and the swarm made itself at home in the first head-quarters under a bush. There it built combs and set up a new brood-nest. That behaviour may be the last resort when no agreement is reached; but naturally in the climate of a country such as Germany the colony could not survive the winter in this manner.

Nevertheless, these are exceptional cases; and we must now examine the deeper causes which lead to an agreement between the swarm bees over the different nesting sites.

Bearing in mind that a swarm normally consists of 10,000–30,000 bees, we may well ask: Which of them decides which of the nesting places to choose? Does each of the bees have a say in the matter, or do they leave the decision in the hands of a small committee whose choice is accepted unanimously by all?

In brief, the answer is that the decision is left entirely in the hands of the scout bees. In order to reach this decision they make use of their dances, with which they announce the nesting sites. These dances of the scout bees not only communicate the location of a nesting place, but also they give exact details about its quality.

When a 'first-class' nesting site has been found then the scouting bees begin a long dance with great vivacity which can last an hour or even longer, instead of just a few minutes as in the case of the forager bees. A fairly suitable home is announced, on the contrary, by a modest and lazy dance which is stopped in a few seconds. In this way the interest must be concentrated immediately on the most favourable nesting site; and it is easily understood that the decision will be made always in favour of the best nesting places announced.

But whether the choice actually made was the best could not be determined solely by observing the bees in the swarm; it was necessary to know also what took place at the different nesting places before the migration. I therefore provided my scout bees with artificial nesting places on an inhabited island or on a flat piece of waste land, making various alterations in the nests themselves.

In the first experiment, two empty boxes were placed at the disposal of the bees. One of them was set up under a tree and covered with twigs; the other one stood unprotected in an open field. Both places were discovered by the scout bees and carefully inspected and were announced to the swarm by means of dances. From these dances alone it could be seen that the two boxes were of different quality; the scout bees which came back from the unprotected place announced their finding through a short and modest dance, while the other group carried on long and lively dances. As a consequence, in a short time the better nesting site received the more attention.

Furthermore, it was observed that marked scout bees which first of all had announced and recommended the unprotected place were gradually influenced by the lively dances of their competitors; then they inspected the other—more favourable—nesting place, and after returning they campaigned for this better home.

That the decisive factor in this case was the protection and the location of the box (not, for example, the construction or the 'furniture' of the boxes) I was able to demonstrate in the following manner. I moved the branches from one box to the other, and at once the scout bees which formerly had announced the shaded nesting place were favourably influenced by the lively dances of those scout bees coming from the newly protected nesting site. In this manner we could lead the swarm into whichever box we wished, merely by exchanging the protective covering.

This is therefore the simple method by which swarm bees come to an agreement: the better the nesting site the more excited the dances of the scout bees, and the more new scout bees become recruited for this new place; the more bees therefore then fly off to this spot, inspect the home and then likewise announce it to the swarm by the same lively dances. When, furthermore, those scout bees which at first had announced the inferior nesting places are won over by the more lively dances of their competitors and as a result themselves inspect this home—so that they can compare the two—then they naturally

choose the better one. Hence nothing more stands in the way of an agreement.

But now there arises a new question: How can the scout bees judge so exactly the quality of a nesting place? Which qualities of a bee home are taken into consideration? Which receive a positive evaluation, which a negative? This question is naturally also of interest to the practical beekeeper, who has for centuries sought to construct the ideal beehive.

As we have already seen, the location of the future dwelling place plays an important part; the most important factor in this case is protection against the wind. However, the wind can change from day to day, and a nesting place which on one day appears to be protected against the wind can on another day have no value in this regard. It is of particular interest that the scout bees take this fact into consideration. They come back again and again to the nesting place, from morning to evening, and they come again on the next day and likewise on the third day, and so on until the migration has taken place. In this manner they can assure themselves that the nesting place will retain its favourable characteristics at least over an extended period of time.

As a matter of fact, I was able to observe that the reactions of scout bees changed when unfavourable conditions were experienced during the period of repeated visits at the nesting site. In one experiment I set up two hives, both of which were situated at the edge of a thicket; one of them had open spaces to the west and was therefore protected against the east wind, whereas the other had the open spaces towards the east, and was therefore protected from the west wind. During days with an east wind the former was preferred by the scout bees, while during those days with a west wind the other was preferred. Since in general west winds prevailed, the swarm finally moved into the former nesting place.

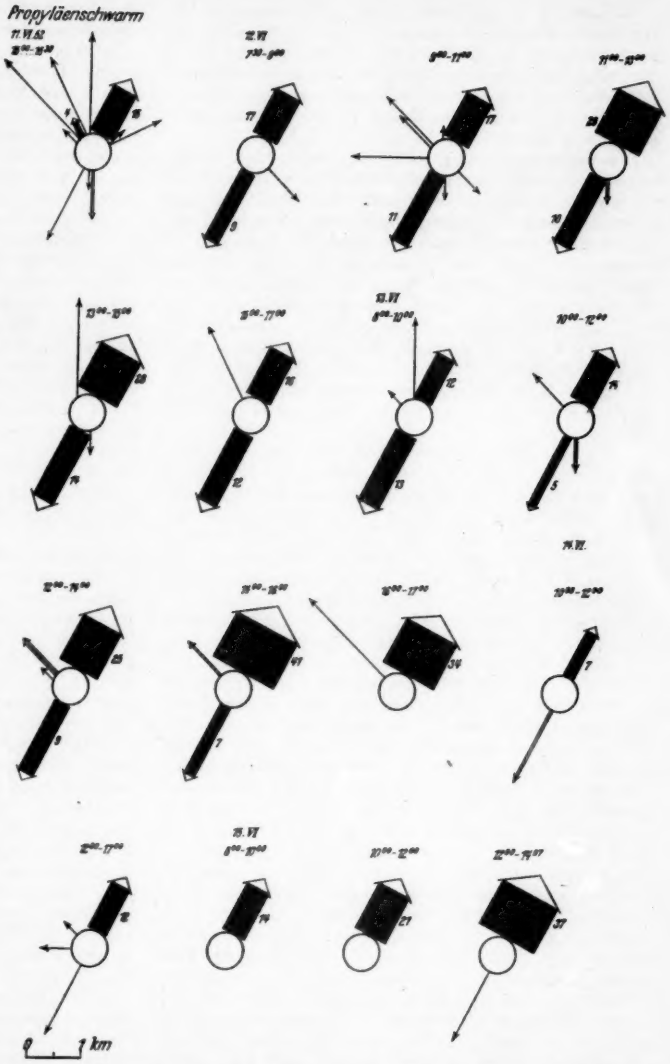

Fig. 2. If two equally strong groups of scout-bees announce two different nesting places, the swarm moves only when one of the groups of scouts gives up its dances. From *Z. vergl. Physiol.*, 37, 263ff., Ab. 3 and 4 (Springer-Verlag, 1955).

In a second case, one of my empty beehives which had been highly favoured by the scout bees from the beginning was suddenly rejected. I was puzzled over the matter until I saw that through a split in the back of the hive ants had invaded the box. Because of this, it could no longer be used as a home for the bees.

On another occasion a hole in the ground—also favoured by the swarm bees—became filled with water during a thunderstorm. Although on the day before a lot of scouting bees were attracted by this possible nesting place, from now on they completely ignored it.

In addition to the location of the hive, the scout bees naturally take other factors into consideration, such as the size and construction. That is easily understood, because the swarm does not move into just any hollow; it must be a hollow space which corresponds in size roughly to an artificial beehive. But it is worthy of note that each swarm does not make the same claims on the size of the hive. A giant swarm prefers a larger nesting site than a dwarf swarm. I once offered to a dwarf swarm—scarcely larger than a man's fist—two hives which during early experiments had been immediately accepted by the scout bees. This time, however, the scout bees would not accept the boxes. Only when I made the space smaller in one of them—by padding it with cotton—was this smaller compartment found suitable to them and the swarm actually moved in.

In addition to size, the art of construction of the new home is taken into consideration. A wooden box is preferred to a basket; a hole in the ground is, on the other hand, preferred to a wooden hive. Perhaps the location of the entrance has also some importance; particularly it is important that no draught can arise in the new home.

The following finding was completely unexpected, namely, that the distance of the future home from the mother colony plays a part. One might suppose, naturally, that the nearer the future home is to the old dwelling place the more it would be preferred by the swarm. But the opposite is the case: if two similar hives are offered, one at a distance of 30 m., the other at 300 m., then the latter is preferred. The biological significance of this choice is immediately obvious: the farther away the swarm moves from the mother colony the more easily are the bees able to acquire new feeding areas from the new headquarters which have not yet been exploited by other colonies.

It is truly astounding that the scout bees can take account of so many different characteristics in looking for a new home; all the more so as they are unable to gain experience in this function during their life.

In this connexion there remains still another problem to be solved: in the normal plan of the division of labour in the bee colony, the function of house hunting is not undertaken like all other tasks. In the case of most bees, the 'profession' of scout does not exist, for many generations may pass without any need for seeking a new home. But when in May swarming-time takes place suddenly, then they must be there and for a few days the fate of the whole race lies in their hands. Is there then in the bee colony a special group of trained scouts, which wait months and even years to exercise their function?

In order to answer this question, I set two empty hives at the disposal of the colony which was preparing in May to swarm. I put up a feeding table close by, where a group of marked forager bees of this colony could feed. First of all they took no interest whatsoever in the empty hives, but only collected around the feeding place. A few days before swarming, I noticed that the interest in feeding dwindled and most of the forager bees remained idle in the hive. Some of them, nevertheless, came back—but not as forager bees. They sipped only a little sugar solution and then they investigated splits in the bark of trees and the mouse holes in the ground in the neighbourhood; and last of all they checked the two hives. There was no doubt that these forager bees had become scout bees.

In this way it was shown that there is no special group of scouting bees in the colony, but that the scouts were recruited at the swarming time from old experienced forager bees. What was truly surprising, however, was that the act of swarming itself did not cause the search for the new home, for house hunting had been taken up a few days before.

Why had these scouts given up the function of foraging at this time? Normally, the bees exercise the function of foraging for the entire second half of their life. The immediate observation of the behaviour of the bees in the colony at this time gave the following information. As all supply chambers in the hive were completely full of nectar and pollen, and as also the honeysacs of the honeybees were filled to bursting point, the forager bees could no longer deliver the nectar to the other bees and they had no other choice than to remain idle in the hive. In such a situation some of them seize the initiative and take over the only other function possible, namely, home hunting.

In this way at the time of swarming everything is bound together in a very reasonable manner: that the function of home hunting, as we have just seen, is associated with an abundance of nectar and pollen provides the guaranty that swarming time always takes place at a time when rich food supplies simplify the setting up of a new home. The young swarm must build new combs, it must raise the young brood quickly and it must bring in enough supplies for the coming winter. All this is only possible during a good food season.

Everyone who has occupied himself in any way with bees will have admired the harmony of their community life. In no case is this community life put to a more strenuous test of self-preservation than at swarming time. The raising of the young queens, the migration of the swarm, the seeking of a new home, the moving into this new home, all demand unanimous decisions from many thousands of bees. But even more surprising are the simple ways by which such unanimous decisions in a bee colony are taken. Nothing more is necessary in the final case in this search for a home than that each bee renders an objective and absolute true judgment of the worth of the newly found home; then the only other thing demanded is that the bee should not adhere to its first choice when other bees have better possibilities to offer.

MARINE SCIENCE IN THE SOUTH-EAST PACIFIC OCEAN

FOLLOWING its policy of arranging discussions on marine science in areas where they are likely to attract new interest, the United Nations Educational, Scientific and Cultural Organization invited its Marine Sciences Advisory Committee and other specialists to meetings in Lima. There can be few places where the power of the ocean is more obvious. The Sun was almost overhead and the shadows west or east, but the air was cool and thick cloud overhead, and the feeding flocks of birds gave evidence that the coastal water teemed with life. The Gulf Stream may be the greatest wonder of the ocean world, but the Peru Current runs it close. There is no tremendous flow of water—probably never more than 10–20 miles a day—and at some times and places it is so weak as to pass unnoticed; but the isotherms run more or less north and south for some two thousand miles, and cold water off the coast of Peru is as remarkable and beneficial as warm water near the Newfoundland Banks and Iceland.

The story is well told by Gunther[1]. The current, the cloud, the coldness of the water, and the richness of the animal life were reported soon after the South Sea was first sighted, and have been keenly discussed ever since. Humboldt, in 1802, was the first to dip a thermometer into the current, and he thought the low temperatures were maintained by a strong northward flow of cold water. This idea was soon

questioned on account of the weakness of the northward current, especially off southern Chile, and in 1844 a French navigator suggested upwelling of the lower layers close to the coast as a cause. This explanation gained ground with the discovery that there was often little or no current close to the shore where the water was coldest but a westerly set, out to sea. The upwelling was attributed to this westerly set and to the effect of the trade wind over the ocean at large. The idea of upwelling was further strengthened when it was learnt that the effect of the Earth's rotation on the north-going current would bring cold water to the surface along the coast.

Biological calamities have always been associated with warming of the water. Gunther notes that Acosta, writing in 1608, described north winds as troublesome and unwholesome, and this is possibly the earliest record of the ills which arise when the usual northward current, upwelling and offshore movement are interrupted. The worst consequences occur when strong north-east trade winds extend southwards into the Gulf of Panama. There is then a southward flow of equatorial water down the Peruvian coast, and in 1891 and 1925 the water temperature off Callao was as much as 10 deg. C. above normal. The rise in temperature kills fish and plankton; but the popular conception of a recurrent series of major catastrophes is an exaggeration, and there is some local resentment about the many popular articles which give the impression that dead and decomposing fish are the rule rather than the exception. Where marine growth is maintained at such a high level it is not surprising that there are occasional setbacks, such as disappearance of the anchovies and migration or starvation among the guano birds, and mortality of fish. The relative importance of the factors which produce these ill-effects is not really known.

The warming of the surface water, together with the associated stratification of the water column and restriction of vertical circulation, favour the swarming of brightly coloured flagellates and related organisms. This growth can be so dense that it discolours the water brown or red, and has such poisonous effects on fish that they become affected and eventually die. The temperature of the water depends on such things as the relative strength of north and south currents, the activity of divergence from the coast and upwelling, and the complex interchange of heat between ocean and atmosphere by radiation, conduction, evaporation and condensation. When the temperature rises, the fish may seek cooler areas or remain at greater depths, inaccessible to the birds. The 'red water' may itself be harmful, or it may bring about the death of the abundant phytoplankton by cutting off the light below the first few feet of water. Sears[2] mentions an instance where plankton nets fished below discoloured water came up loaded with a yellow-brown slime from decaying phytoplankton. On this occasion there were reports of some dead fish and a putrefactive smell; but as a whole the fish and bird life seem to have been little affected.

The physics is as difficult as the biology. Gunther gives a bold outline, but has to emphasize the extraordinary variability of the current in almost every particular, drift, temperature, breadth and colour. One can only guess what will happen when the theoretical workers now studying the Gulf Stream consider this complementary problem. The northward current and the upwelling may prove to be dynamical consequences of westward drift induced by the winds far out over the ocean as well as of the local winds. The facts observed by Gunther (ref. 1, p. 205) suggested as much. The details of wind distribution and the bottom topography may sometimes cause upwelling at a distance from the coast and favour the development of counter-currents close inshore. The submarine topography, shape of the coast and persistent features of the distribution of air pressure and wind associated with the topography and character of the land must give the pattern a bold outline like that reported by Gunther and others; but visiting scientists have perhaps set up models which are too simple and have dismissed observations which do not conform to them. Relations between the current and weather are also not so simple as has been supposed: heavy rains are generally associated with the southward movement of warm water from the Gulf of Panama, but 1955 was very cold and very wet.

The most urgent needs are for quantitative studies of the horizontal and vertical exchanges of water and interchange of heat with the atmosphere, and of the factors which promote discoloration of the water. Some authorities hold that the swarming flagellates enrich the surface with phosphate, whereas others suggest that enrichment of the surface water by bird droppings in the absence of downward mixing favours the swarming. It would be particularly useful to have a more detailed understanding of the effect of upwelling on productivity and the distribution of the fish; the coldest water is not itself the richest.

It is difficult to urge the need for more work without risk of appearing to undervalue what is already being done, and the discussions at Lima showed that Dr. E. Schweigger has by careful and persistent observations acquired a very wide experience of the trends and eccentricities of the problem. This experience will go a long way to improve understanding of the fluctuations in the productivity of the area, and in the amounts of guano deposited on the islands.

There are other marine problems, particularly the heavy swell and surf; this often makes poorly sheltered harbours unusable and renders the task of erecting artificial protection expensive and difficult. There can be no country where a practical system of wave prediction might be more useful, and since little or no meteorological information is received from the vast ocean to the westward it would be an ideal place to investigate the possibilities of using recordings of microseisms to gain warning of the approach of swell.

Other problems of the east Pacific Ocean were discussed. Particular attention was paid to the need for a quantitative survey, with closing nets, of the layer of water with a very low oxygen content found between depths of 300 and 1,000 metres in 5°–25° N. off the American coast.

Unesco Advisory Committee on Marine Science

The Committee met for the first time during October 22–24, though the ground had been prepared by an interim committee in Tokyo (*Nature*, **177**, 353; 1956), and by reports on the needs of marine science from national commissions and international organizations. The Committee considered a wide range of problems and recommended direct or indirect support for work that will cultivate interest in the

oceans and understanding of their behaviour, especially in countries where little attention has been paid to them. It also urged support for organizations engaged in perfecting various aspects of the science to the point where they can become really effective in practical problems.

The recommendations provided for the arrangement of symposia in countries most likely to profit from the visit of marine scientists, and for support of international meetings which seem likely to attract the attention of scientists who are effective in other fields. There was also support for regional meetings. The use of fellowships and travel grants was dealt with, and useful steps taken to help in such matters as bibliographies, text-books, translations, regional guides, joint planning, and exchange of facilities, scientists and equipment.

The funds available are too small for all the things the Committee had in mind; but the members took a realistic view of the difficulties and will reconsider their proposals and be more specific about priorities as the year advances.

Many of the problems that have to be solved require observations in regions where there are no research vessels, and the exploitation of new techniques on a scale beyond the present facilities of all countries, and after long discussion the Advisory Committee recommended that Unesco should ask its General Conference to set up a convention to arrange for an international research ship. It was realized that many governments would not subscribe without the prospect of immediate economic benefits, and it was emphasized that the long-term nature of the work must be stated very frankly. The idea is for a strictly co-operative venture to make observations which will be studied by existing laboratories. The Committee recognized that the difficulty of making such a complicated organization effective would deter the larger countries, but hoped that the example of the European Centre for Nuclear Research and the success of international co-operation in cultural, medical and humanitarian, and other non-political fields would help to persuade them. It was noted that there is increasing demand for very special information about the oceans from international committees concerned with atomic waste disposal.

G. E. R. Deacon

[1] Gunther, E. R., Discovery Reports, **13**, 107 (1936).
[2] Sears, Mary, *Deep-Sea Research*, **1**, 141 (1954).

THE CALDER WORKS NUCLEAR POWER PLANT

THE BRITISH NUCLEAR ENERGY CONFERENCE

A HIGHLY successful symposium was held at the Central Hall, Westminster, during November 22–23, 1956. The sessions of most general interest were attended by more than two thousand members, including a large overseas contingent. It is understood that the large official United States party included officers of a private organization which is carrying out, under an Atomic Energy Commission contract, an impartial, objective and far-reaching cost comparison between the types of power reactors represented by Calder Hall and pressurized water reactor, Shippingport; it is hoped that the results of this study will be made public early in 1957.

The symposium was divided into five sessions, during which nineteen papers were presented. The papers, which were introduced in groups by reporters, will be published, together with the discussions, in the April and July issues of the *Journal of the British Nuclear Energy Conference*. Sir John Cockcroft presided over three sessions, "Introduction and General Design", "Technical Research Problems" and "Future Developments and Summary". The sessions on "Engineering Design" and "Light Engineering and Electrical" were presided over by Mr. W. L. Owen and Mr. J. Eccles, respectively.

The symposium was opened by a paper presented by Sir Christopher Hinton, entitled "The Place of the Calder Hall Type of Reactor in Nuclear Power Generation"; this first session, which was completed by papers by Mr. R. V. Moore and Mr. B. L. Goodlet on the 1951–53 Harwell design study, and by Mr. Moore on the design and construction of the plant, traced the history of the project and put the gas-cooled graphite-moderated reactor into its correct perspective in the atomic energy field. Although some facts which had already been published were repeated, Sir Christopher said that many new details would be revealed by experts who had taken important parts in the research, development, design and construction stages; furthermore, each paper gained from the unique comprehensiveness of the whole.

Sir Christopher referred to the initial considerations which, in 1946, influenced the choice of reactor by the newly formed British organization. The original intention, to build a water-cooled graphite-moderated pile of the Hanford type, was departed from because the dense population in the United Kingdom made the inherent stability of the gas-cooled type more desirable. From the beginning it was appreciated that it might be possible to put the whole system under pressure and to extract useful heat, especially if extended heat-transfer surfaces were employed on the fuel elements. Owing to the urgent defence requirements for plutonium, it was not possible to utilize these ideas for BEPO or Windscale, but the general studies of this type of reactor were continued. When a new requirement for plutonium arose it was possible to modify the design parameters for this purpose and the first Calder Hall reactor was approved in March 1953.

Sir Christopher emphasized strongly the fact that Calder is designed and operated to produce military plutonium, with electricity as a by-product; the industrial cost of power from reactors of this type can only be determined from designs for optimal electrical power. During the construction of Calder, however, a study was initiated, later to become the basis of the 1955 White Paper, which surveyed the national requirements and suggested that reactors of the Calder type could produce electricity at about 1·0*d.* per unit sent out, with plutonium as a useful by-

product, which might, however, need to be burnt in more highly rated reactors.

Sir Christopher said that the Calder reactors have the very great immediate advantages of using natural uranium as fuel and not requiring any exceptionally novel materials or techniques in their construction; they are, however, heavy, cumbersome and expensive in capital cost. He showed how weight and cost had been reduced with time in the case of other types of generating equipment and, drawing analogous curves for the Calder type of plant, suggested that costs of about 0·5*d*. per unit sent out could readily be achieved by 1975. He concluded that such reactors would still be built in twenty to twenty-five years time, although the Atomic Energy Authority was concurrently pursuing the development of other more highly rated systems.

Mr. R. V. Moore described the Harwell design study carried out during 1951–53 and explained the important factors which led to the main decisions. The key items were the size of the pressure vessel which might be built, the maximum fuel element temperature and the extent of the carbon dioxide–graphite reaction. By a careful study of other similar structures, it was decided that a cylindrical pressure vessel of 37 in. internal diameter could be safely fabricated on site and operated at 100 lb./sq. in. pressure with a maximum temperature of 400° C. A maximum fuel element temperature of 400° C. was also selected and experiments during the design study showed this to be feasible. A critical experiment on the rate of reaction between carbon dioxide and graphite also showed that, although influenced by irradiation, it was not likely to prejudice the design. Thus, in 1953 it was possible for the Industrial Group to take up the work, and Mr. Moore, who transferred to Risley at that time, went on to describe the main features of the plant and the special features of construction, of which the very tight time-scale and the need for extreme cleanliness were perhaps most interesting. One major doubt which remained until the reactor was operated was the exact enrichment, if any, which would be required. In fact, the reactor operates easily on natural uranium.

In the discussion which followed these general papers, universal tribute was paid to the United Kingdom Atomic Energy Authority for its wisdom, courage and energy. Sir Claude Gibb called for an immediate decision to increase the power reactor programme. Other representatives of the firms now designing commercial stations of this type for optimal power production discussed the main changes they are introducing to reduce costs. Increased size is very important and here the feasible size for a pressure vessel is still the limitation, although much progress has been made. In order to obtain a good load factor, charging and discharging on full power have been introduced and special attention was paid to maintenance problems. It is forecast that the export market may require two types of reactor—one of about 60 MW., with electricity costs of about 2*d*. per unit sent out, for countries short of conventional power, and a smaller 'package' type, requiring enriched fuel. Difficulties which were mentioned include the shortage of scientists, steel and material-testing reactors. Mr. Brown (Central Electricity Authority) also pointed out that electricity costs for conventional stations are continually being reduced, so that atomic energy is faced with an increasingly difficult target. Mr. W. L. Owen (director of engineering, Risley), in reply, said that two further reactors of the DIDO type are under construction, at Harwell and Dounreay; the requirement for the 'package' reactor is under consideration. He emphasized the importance, in Britain, of making the correct decisions regarding the type of reactor to build and of keeping ruthlessly to the programme. He was aware of the technical progress in conventional power generation, but felt that increases in costs of fossil fuels would outbalance this, to the advantage of atomic energy.

From an overseas member there was a question, referred to again later in the meeting, on the inherent safety of the reactor. Sir Christopher Hinton and others replied to this with great thoroughness. The important point is that the loss of coolant, or any other such failure, cannot result in an increase in reactivity, so that there is no possibility of a 'runaway'. Many other types of failure, and combinations of failures, have been studied from the point of view of district contamination and it has been concluded that the magnitude of the worst hazard is comparable to that of transport and storage of chlorine. The effluent problem from normal operation is of minor importance and there will be a tendency to reduce siting restrictions.

In the session on "Technical Research Problems", greatest interest was shown in the problems of heat transfer and metallurgy of fuel elements and on nuclear physics. Discussion on heat transfer from the fuel elements centred upon the use of transverse fins in Calder in contrast with longitudinal fins in the Windscale reactors. Several contributors emphasized the need for a comparison of performance based on heat transfer and pressure drop data. Others pointed out that any such comparison depended upon the particular reactor to which the results were applied. One member, Mr. Margen (Sweden), introduced an interesting comparison between the transverse finned can and packed columns of various types.

On fuel elements, emphasis was placed on the heat-treatment of uranium to avoid irradiation effects, on the strength and method of support of the fuel elements and on the properties of the magnesium can. A fine random grain in the uranium has been demonstrated to be best, and an elegant method of obtaining this, involving continuous high-frequency induction heating, has been developed; the effects of minor impurities, previously unconsidered, have had to be studied in a manner analogous to the work on the breakdown of austenite in steels. The importance of creep, and the intricacies of this phenomenon under irradiation, were referred to and the decision to stack the cartridges vertically was questioned. In reply, it was said that the problems of this arrangement, which has the merit of simplicity, were appreciated at an early date and great efforts have been made to obtain quantitative data, at the same time preparing alleviating measures. Some fuel elements have been discharged for examination and there is reason for believing that the original decisions are basically sound. Creep and support problems can be overcome by ingenious design in future reactors requiring much longer irradiations. A more persistent problem will be the ability of the magnesium can to accept the inevitable deformations without cracking; a particularly interesting aspect of this is the phenomenon of void formation at grain boundaries under certain conditions of temperature and strain rate.

Dr. B. F. J. Schonland (deputy director, Atomic Energy Research Establishment) discussed the nuclear physics problems and asked to what extent

theoretical calculations could replace the expensive experiments. In reply, it was said that experiments of the exponential type will continue to be necessary, but it is essential also to develop an academic basis on which to explain the results. In the industrial reactors there will be spare reactivity which may be used either for flattening or for increasing the irradiation level of the fuel elements.

In considering the pressure vessel, greatest attention was given to the problems of brittle fracture, site fabrication, inspection and pressure testing. A special steel of superior notch ductility was selected and controlled by transition-temperature tests. Plate examination and welding procedures of the highest standard were required and all butt welds were examined by X-rays, with crack detection of important fillet welds. On completion, the vessel was fully stress-relieved and both pressure and vacuum tested; all these operations were carried out with a large number of strain gauges in position, so that a complete picture of stresses and deformation was obtained. All speakers agreed with the necessity to use steel of good notch ductility, but one commented that it is very difficult to obtain the necessary large forgings to such a specification.

The steam-cycle analysis was complicated initially by interlocking variables in other fields and later by the emphasis on plutonium production, which prevented the use of optimum steam conditions. However, the dual pressure cycle adopted has now been shown to be very satisfactory under the practical conditions applicable, especially the relatively low reactor outlet temperature (336° C.) Modest improvements in the latter will bring rapid increase in efficiency. The view was expressed that multiple-pressure cycles will remain advantageous, however high the fuel element temperature, since the additional efficiency will outweigh the extra complexity and cost.

In the session which covered reactor control and instrumentation and the detection of faulty fuel elements, a most interesting contribution was made by Mr. Stretch (works manager, Calder Hall), who commented from the point of view of the user. He thought that it will be possible in due course to remove some of the instruments as experience shows which ones give the best indication of what is happening in the reactor. This point was not received very sympathetically by the authors of the paper on instrumentation, who felt that they had been quite severely restrictive with regard to numbers and types of instruments installed. With regard to faulty fuel element detection, however, the equipment was consciously made more comprehensive and flexible than may be found necessary for future reactors, when the requirements are more fully understood.

Mr. Stretch was very appreciative of the flexibility permitted in the patterning of the control rods. During the first scheduled shut-down, opportunity has been taken to bring about a second approximation and he thought a further adjustment will be advantageous later. He also said that the practice has been adopted of using the variable speed motors of the circulators to change the power level; very smooth adjustment of load can be obtained by this means.

The final session on further development was undoubtedly most important and inspiring. The subject was introduced by a further paper by Mr. R. V. Moore, "Development of Gas-cooled Reactors for Power Production".

Mr. Moore outlined the elements of power cost analysis for reactors and used this to estimate the cost of power from Calder if this plant were to be used as a power station with no value attributed to the residual plutonium. If the plant were operated at 80 per cent load factor and the fuel elements, costing £20,000/tonne, were irradiated to 3,000 megawatt-day/tonne, the cost per unit sent out would be about one penny, of which about half would be capital charges and one-third fuel consumption charge. The importance of achieving high irradiation levels in the fuel was emphasized, especially up to about 2,000 megawatt–day/tonne.

Considering early improvements for power production, over the Calder design, the most obvious and effective means is to increase the size of the reactor. This not only reduces the capital charges per kilowatt but also provides excess reactivity which may be used for flattening, thus improving the factor for mean/maximum channel output. Combined with a modest pressure increase, say to 150 lb./sq. in., a reactor of 400–500 MW. heat could be built using 3-in. thick plate; this would have a marked effect on cost without departing from the experience being gained at Calder.

Raising the maximum fuel element temperature improves several economic factors, but may increase fuel costs. Relatively little increase can be obtained from magnesium-canned elements. Other materials have lower thermal conductivity; this, coupled with the higher heat fluxes required, makes fins progressively less effective. The alternative is to increase the primary surface and this leads to poorer nuclear conditions and the probable need for enrichment. Nevertheless, if fuel element temperatures of 600° C. could be obtained, in a reactor of 400 MW. electrical the overall efficiency would be 31 per cent, and the rating 5·8 MW./tonne, compared with 25 per cent and 2 MW./tonne for the larger Calder design.

The need for enrichment leads to consideration of plutonium recycling. The ideal here might be to reach an equilibrium condition in which, on processing irradiated fuel elements, the plutonium is returned, some depleted uranium is rejected and the make-up is natural uranium. This would enable perhaps three times as much heat to be extracted from a given quantity of uranium and at the same time allow reactors which initially require enrichment to be fed with natural uranium. The economics of this system are not yet known, an important unknown factor being the cost of fabricating fuel elements containing alpha-active plutonium, but the possibilities are attractive.

The use of ceramic fuels, such as uranium dioxide and uranium carbide, will probably be required in order to raise the temperatures above about 600° C. In addition to their much higher softening point, these fuels are expected to be more resistant to irradiation and to attack gaseous coolants. It may be desirable also to disperse the fuel throughout the graphite moderator. With gas outlet temperatures of 800° C. overall efficiencies of 40 per cent could be obtained, with further considerable reduction in capital costs. There is also the prospect of gas-turbine cycles.

Mr. Moore concluded that there was a satisfying field for future development of gas-cooled reactors, and this was the view of all the succeeding speakers. Dr. J. V. Dunworth (Atomic Energy Research Establishment) concurred, and endorsed particularly the potentialities of recycling plutonium, which he thought might enable 10,000 megawatt–day/tonne to be obtained from natural uranium. Mr. Davey

(works general manager responsible for Calder) compared the time scales for commissioning the first Windscale pile with those for Calder. Despite the much greater complexity of the latter, the work had gone remarkably smoothly. This, together with the fact that the operating figures were very near the design figures, convinced him that he had a very satisfactory plant to operate.

On this note of mixed satisfaction with the present and high expectation for the future, Sir John Cockcroft closed a highly successful and possibly historic conference.

OBITUARIES

Prof. C. A. Chant

With the death of Clarence Augustus Chant, professor emeritus of astrophysics of the University of Toronto, on November 18, in his ninety-second year, Canadian astronomy has lost the one who has often been referred to as its 'dean'. He was the founder of the Department of Astronomy at the University of Toronto and of the David Dunlap Observatory and editor for fifty years of the *Journal of the Royal Astronomical Society of Canada*. More than anyone else, he had been responsible for the growth of that Society from a small Toronto group to a nation-wide society which is truly representative of all Canadian astronomy, both professional and amateur.

Chant was born near Toronto on May 31, 1865. Educated in country schools, he was a school teacher for a year before entering the University of Toronto. After his graduation as an honours student in mathematics and physics in 1890, he was appointed in the following year to the teaching staff in physics at the University. During his early years there he experimented with Hertzian waves and is credited with transmitting the first wireless message in Canada.

By 1904 Chant had become engrossed in astronomy, had become president of the newly chartered Royal Astronomical Society of Canada and had won recognition for astronomy in the creation by the University Senate of a teaching department and of a graduating option of the mathematics and physics honours course. Under his enthusiastic leadership, the Royal Astronomical Society of Canada, then restricted to Toronto, expanded to include centres all across the country and embarked upon publication of its *Journal* and annual "Handbook", both of which were edited by Chant from their inception in 1907. At the same time, he expanded the teaching of astronomy at the University, and among his students were numbered nearly all the Canadian astronomers who were to develop observational astronomy in Canada during the first half of the century—at Ottawa, at Victoria and later at Toronto. Chant himself felt hampered at Toronto by the lack of an observatory, and as early as 1912 he began to strive to acquire for the University a major research telescope. It was not until 1928 that these efforts promised to come to fruition, when Mrs. Jessie Donalda Dunlap offered to present to the University, in memory of her late husband, an observatory to bear his name. Chant devoted the next seven years to the plans for this observatory and its 74-in. reflector, which was built to his specifications in Britain by Sir Howard Grubb Parsons and Co., Ltd., the first of a series of similar instruments made by that firm. The David Dunlap Observatory was opened on May 31, 1935, and Chant, its first director, retired at the age of seventy.

During the years when he lacked adequate observing facilities in Toronto, Chant made a number of visits to American observatories and led five solar eclipse expeditions. The most successful of these was an expedition to Australia for the 1922 eclipse; he and R. K. Young obtained at that time one of the first verifications of the Einstein prediction regarding the deflexion of starlight by the Sun's gravitational field. He also had success as a writer of popular science articles, of school and college physics text-books and of an excellent popular astronomy book, "Our Wonderful Universe", which was published in Canada, in Britain and in five foreign language translations.

Chant's degrees included a Ph.D. from Harvard and an honorary LL.D. from Toronto. He was Fellow of the Royal Society of Canada, of the Royal Astronomical Society in Britain, of the American Physical Society, and member of the Société Astronomique de France and of the Astronomische Gesellschaft.

Since 1935 Chant had lived in retirement at Observatory House near the David Dunlap Observatory. Until a few weeks before his death he had maintained an active interest in the work of the Observatory and had continued his writing and his editorial activities. His mind remained alert and occupied with the many things that interested him, but especially with astronomy, the science to which he had devoted his long life. J. F. Heard

Lady Flinders Petrie

By the death of Lady Flinders Petrie on November 23, the archæological world has lost a striking personality. As a girl, her interest naturally turned to geology owing to the friendship between her family and that of Prof. Seeley, the geologist, and this interest remained with her all her life. But after her marriage she devoted herself to her husband's work. She accompanied him in all his expeditions to Egypt, to Sinai, to Palestine, enjoying the sense of freedom which camp-life gives.

When working with her husband she did not take part in the actual excavation, but helped in the measuring of buildings and in the drawing of the finds. She always called the roll of the workmen as they came at sunrise to the excavation, she visited the work at intervals during the day, and in the evening, when the workmen brought the day's finds to the camp to be inspected and their value assessed by Petrie, she kept tally of the amount due to each man. She was present at all the spectacular finds—the jewellery of the First Dynasty, the treasure of Lahun, and that dramatic moment when Petrie identified an apparently worthless broken mud figure as an ivory statuette, the only known portrait of the builder of the Great Pyramid. She did two excavations herself: the first when she and I together opened up the Osireion at Abydos, and in the fol-

lowing year she cleared seven sculptured tomb-chapels at Saqqara. But when her husband left the Egypt Exploration Society, the whole burden of raising funds for his work fell on her. It was then that she developed that gift of rousing not merely interest but also enthusiasm, and it was through her efforts that he was able to continue his work, with only the break of the First World War, until within three years of his death. After his death she devoted herself to preparing his unfinished manuscripts for publication, and on her return to England she saw them through the press.

Lady Flinders Petrie herself wrote two books. Her report on her excavations at Saqqara was published under the name of "Seven Memphite Tomb-Chapels". In this the carefully drawn plans and details of building show her accurate work, and the letterpress also shows the same meticulous accuracy. Her other book, "Early Egyptian Hieroglyphs", though less imposing in size, is perhaps the more important of the two. For anyone studying the actual meaning of the hieroglyphic signs and the objects which they represent, this book is indispensable. The signs are drawn from examples of the First and Second Dynasties, and the identification of the object which the sign represents often throws light on the root meaning of the sign when used in later writings. It is a book with which every student of Egyptology should be well acquainted.

M. A. Murray

Prof. O. W. Tiegs, F.R.S.

With the death on November 5 of Prof. O. W. Tiegs, Australia has lost a great zoologist. An avowed disciple of descriptive morphology during an age when most biologists are turning more and more towards experimentation, Tiegs has an assured place in the history of zoology.

Born in Queensland in 1897, Oscar Werner Tiegs received his early education at Brisbane Grammar School and then proceeded to the University of Queensland, obtaining his B.Sc. with first-class honours in biology in 1919. It was his original intention to enter the medical profession; but, fortunately for zoological science, there was no medical school in Queensland and so he decided to continue his studies in zoology. After carrying out postgraduate work on insect metamorphosis and on the biological control of prickly pear, he joined the staff of the Zoology Department of the University of Adelaide in 1922, obtaining his D.Sc. from that University in 1925. In the same year, he was appointed to a lectureship in the University of Melbourne. Three years later, he was awarded the Syme Prize and Medal, one of Australia's foremost scientific prizes. The award of a Rockefeller Fellowship enabled him to spend a year working in Europe. Most of this time was spent in Cambridge and Utrecht. After his return to Melbourne, he was appointed associate professor of zoology, a post which he held until 1948, when he was called to the chair on the retirement of the late Prof. W. E. Agar.

Prof. Tiegs was elected a Fellow of the Royal Society in 1944 and was a foundation member of the Australian Academy of Science. His research activities were mainly in the field of nerve and muscle histology and of arthropod embryology. His study of the embryology of myriapods and insects, recorded in a magnificent series of memoirs, culminated in the development of his well-known views on the ancestry of the insects. Just a few days before his death, he completed a masterly review of the whole problem of arthropod evolution. In some of his more recent research activities, he returned to a study of the histogenesis of flight muscles in insects. All his published work was superbly illustrated, for Tiegs had great artistic ability. To watch the metamorphosis of a plate, from the rough pencil sketches made at the binocular microscope to the finished work ready for reproduction, was indeed a fascinating spectacle.

By nature, Tiegs was a shy and reserved man, more at home in the laboratory than at the committee meeting or the social function. He possessed a keen sense of humour and a fine appreciation of art, literature and music. To share with him the pleasures of a musical evening was a joy indeed. His death is a severe blow to zoology and a great personal loss to those who have enjoyed the privilege of working in his department.

A. M. Clark

Mr. George Patchin

George Patchin, born in 1877, died on September 7 after a long illness. He entered the Royal School of Mines in 1895 and obtained the associateship of the College with first-class honours in 1898. He was also awarded the Bessemer Medal, presented to the best student of the year.

In 1898, Patchin was appointed lecturer in metallurgy at Birkbeck College, London, and remained there until 1912 when the department was closed and the work was transferred to the Metallurgy Department of the Sir John Cass Technical Institute. He joined the Cass department under the late Mr. C. O. Bannister, whom he succeeded in 1919. Patchin published several papers, chiefly on cupellation, both independently and in collaboration with Bannister. During the First World War, he undertook investigations in the Department for the Inventions Branch of the Ministry of Munitions and served on several committees of that Ministry.

He succeeded the late Dr. C. A. Keane as principal of the Sir John Cass Institute in 1926, but continued also in his post as head of the Metallurgy Department, and he held both posts until his retirement in 1945. He was greatly attached to the interests of Sir John Cass's Foundation, and in his work for the Institute during more than thirty years his constant purpose was to advance the standards of the courses both in his own Department and later in the other departments which came under his care.

In 1931, Patchin was engaged in an important extension of the Institute building. He devoted great care to this work, which unfortunately had to be considerably curtailed because of the economic depression; but he justifiably took great pride in the results achieved. During the Second World War, much of the normal work of the Institute had to cease. The training of navigating officers for the merchant navy and of radar mechanics for the R.A.F. was undertaken under conditions that were often both difficult and uncomfortable. It became impracticable to hold most evening classes, and students attended their courses in the science departments at week-ends. Although there was major damage to the building, particularly in an air raid in 1941, he never allowed work to be brought to a standstill.

Patchin took a particular interest in all branches of metallurgical education. He was an active member

of the Bursaries and Lectures Committee of the Company of Armourers and Braziers from the time when it was set up in 1926 until its activities were brought to a close by the outbreak of war in 1939. He served on, and was chairman of, metallurgical advisory committees of the City and Guilds of London Institute, and he gave much time to this work after his retirement.

He was meticulous and economical in his administration, and decisions were never taken without careful consideration. His somewhat austere manner tended to conceal his essential kindness and the satisfaction he found in helping others. His first wife died in 1931 as the result of an accident. He is survived by his second wife and by the two daughters of his first marriage. A. M. WARD

NEWS and VIEWS

Oceanography at Monaco: Captain J. Rouch

CAPITAINE DE VAISSEAU J. ROUCH recently retired from the directorship of the Oceanographical Museum of Monaco on reaching the age of seventy-two and a half years. He had held the post since the death of Dr. Richard in 1945. Owing to successive monetary devaluations, the original endowments of the foundation had become of derisory value, and it redounds greatly to the credit of Rouch's efforts that the vast museum and its companion institute in Paris can now function on the funds produced by entrance fees paid by visitors. During his term of office, the yearly tally of visitors rose from 170,000 to 560,000. Rouch was a collaborator of Jean Charcot during his second Antarctic Expedition of 1908–10 in the *Pourquoi-Pas ?*, and was responsible for the meteorological and oceanographical observations in addition to those on atmospheric electricity. That polar work of his was published in three excellent memoirs of high repute. After his return from the Charcot expedition, Captain Rouch was elected professor of meteorology, oceanography and hydrography at the École-Navale, and was, in 1937, made professor of physical oceanography at the Paris Oceanographical Institute, which had been founded and endowed by Prince Albert I of Monaco in 1906. During the years 1943–48 he published his three-volume treatise on physical oceanography. From his pen have come numerous publications on marine meteorology, on the polar regions, and on the Mediterranean Sea, and his writings on hydrography and atmospheric electricity amount to a very impressive total. The many oceanographers who would readily proclaim Rouch the greatest living writer on descriptive oceanography would add their meed of praise for the service he has done in recording so much of the history of the subject in a large array of books and papers which are a delight to read. A facile and elegant writer, he has the attractive habit of adorning his pages with effective citations from the classics. To read Rouch on the subject of the Bosporus, for example, is to read much about Jason, Herodotus, Darius, Xerxes and other famous men of ancient days. Rouch is a vice-president of the International Association of Physical Oceanography, a member of the French Marine Academy, and has, since 1946, been a corresponding member of the Academy of Sciences.

Captain J.-Y. Cousteau

CAPTAIN JACQUES-YVES COUSTEAU, distinguished for his work on underwater exploration made possible by the aqualung developed by him in association with Émile Gagnan, is forty-six years of age. Well known to the general public because of his highly-successful film, "The World of Silence", Cousteau's first experiments with self-contained underwater breathing apparatus date back to 1937. It was in 1944, in conjunction with Commandant Tailliez, that he established the "Groupe d'Études et Recherches Sous-Marines" (G.E.R.S.) for the study of the physiology and techniques of diving. Between 1947 and 1949 he was busy fitting out the vessel *Ingénieur Élie-Monnier* as an oceanographical ship, and was in command of her when he attended the unlucky trials of the Piccard bathyscaphe off the Ivory Coast. The participation of the French Navy in that expedition, and the subsequent signature of the Franco–Belgian convention in respect of bathyscaphe *F.N.R.S. III*, were brought about by the Museum's new director. Captain Cousteau has himself made two bathyscaphe dives to 1,450 and 1,600 metres depth, respectively, and holds the distinction of taking the first colour photographs and colour films by artificial lighting while diving free style. His own free-diving exploits have taken him down to 90 metres depth. Much occupied with underwater photography, submarine television and related activities carried out in great measure from the oceanographical research vessel *Calypso*, bought and equipped with private money obtained by him, Cousteau has recently aroused great interest by his new technique of anchoring ship in the deep-sea to a slender cable of nylon. Having so anchored the *Calypso* in 4,000 metres of water, with a cable-length no more than 1½ times depth sufficing well for roughish water, Cousteau is confident that his method has no ocean depth limit. New winches of his design are under construction for the purpose in France at the present time.

Aerodynamics at the Royal Aircraft Establishment: Mr. L. F. Nicholson

MR. L. F. NICHOLSON has resumed his duties as head of the Aerodynamics Department, Royal Aircraft Establishment, on his return to Farnborough after a year at the Imperial Defence College; his promotion to the rank of chief scientific officer has been announced. Mr. Nicholson was educated at King's College, Cambridge, graduating in mechanical sciences in 1939. During his earlier years at Farnborough he was a member of the Engine Department, and worked on the aerodynamics of engine cooling. During 1947–51 he controlled an experimental group concerned with the design and operation of supersonic wind tunnels, and in 1951 he was appointed head of the supersonics division of the Aerodynamics Department. In this period he became well known to the aircraft industry, since the design problems of supersonic aircraft and missiles were making considerable demands of research workers. The Aerodynamics Department comprises a formidable research unit, since it embraces the aerodynamic facilities of the Royal Aircraft Establishment both at Farn-

borough and at Bedford. The late Dr. G. P. Douglas led the Aerodynamics Department for many years, and, upon his retirement in 1953, Mr. Nicholson was appointed as his successor.

The Electricity Bill

The debate in the House of Commons on December 17 on the second reading of the Electricity Bill had several features of scientific and technical interest, quite apart from its importance in relation to the generation and distribution of electricity, particularly of that generated by nuclear power stations. Further tributes were paid to the achievements of scientists and engineers at Calder Hall and elsewhere, but the debate centred largely around the Herbert Report, which had not previously been discussed in the House. Particular attention was directed to the question of research and to the importance of management and the human factor. Mr. J. Callaghan had expressed some concern as to the co-ordination of research, and Mr. Albu also had emphasized the importance of such co-ordination in relation to the large-scale research on storage, heating, etc., which is required.

In reply, the Parliamentary Secretary to the Ministry of Fuel and Power, Mr. D. Renton, said that while the area boards will carry on their own research, the results will be pooled with the Electricity Council, which would also conduct research on its own behalf. He did not, however, meet the specific criticisms of the Herbert Committee as to the volume of research. More specific attention was directed to the question of management, particularly to the importance of attracting a sufficient proportion of the ablest administrators and technologists. In regard to this, the Herbert Committee was highly critical and its recommendations found general support. The Minister, in opening the debate, had said that, while the Government is giving serious thought to the matter and appreciates the force of the comments made both by the Fleck Committee and the Herbert Committee, it is unable to act on the recommendations regarding the disparity of rewards for those at the head of a nationalized industry compared with those in corresponding positions in private industry; nor did Mr. Renton add to this in replying on the debate. Mr. C. R. Hobson pressed the necessity for staff training and of providing avenues for promotion to the top for suitable talent from all levels, while the importance of attention to the appointment, selection and promotion for the lower managerial posts was stressed by several speakers, Sir Keith Joseph pointing out also that the failure to pay high enough salaries at the top levels of management adversely affected, as the Herbert Report emphasized, the position of the middle management and technical staff. It was clear that the House was not satisfied that adequate steps have been taken to deal with a matter which determines the efficiency of the management of the whole industry. This point was firmly made by Mr. Geoffrey Lloyd, who incidentally paid a tribute to the value of the research carried out on a boiler plant to consume low-grade fuel, as well as by other speakers, and the debate established that the recommendations of the Herbert Committee are largely accepted by Parliament, independently of party lines. Mr. Albu stressed the value of joint consultation at all levels, and the importance of the human factor, not only in management but also throughout the industry, is fully appreciated.

Scientific and Technological Education

The "Rationalist Annual" for 1956 (pp. 96. C. A. Watts and Co., Ltd.; 3*s*. 6*d*.) includes a forthright article, "The Chaos in Scientific Recruitment", by Prof. H. Levy, criticizing the methods hitherto adopted to increase the supply of scientists. The acute shortage of science teachers is only one aspect of a shortage which has caught both Government and industry unawares. Not only is the Atomic Energy Authority without more than one-tenth of the scientists it needs on its staff to direct research groups of a dozen or more juniors, but also in 1955 the Services recruited less than half the graduate scientists, especially those with degrees in engineering, physics and mathematics, which they required. Prof. Levy stresses the importance of removing barriers to the fullest exchange between industry, industrial research and practice and so-called academic isolation, and that the fundamental need is to review the whole educational system, from five to twenty-five, to ensure that at each stage facilities exist for bringing out the full potential energy of the whole population and encouraging its interest in directions that are most desirable socially. The prospective 'bulge' in the number of senior pupils or university students was an opportunity for which we should have been preparing during the past ten years, and Prof. Levy remarks that while normal academic procedure provides for the passage from theory to practice, society has not yet provided for the equally important transition from practice to theory. This, he suggests, is largely the business of industry, the research laboratories of which could provide the basic structure for such developments if they extended their scope by the provision of instructional laboratories and, where possible, used personnel engaged on research. Lord Chorley contributes an article on "Freedom of Discussion To-day", dealing more particularly with the question of libel and with the guidance which American experience offers Britain.

International Exchange of Students

The ninth annual report of the International Association for the Exchange of Students for Technical Experience records another increase of 558 in the number of students exchanged, the 5,711 exchanged in 1956 bringing the grand total to 28,668. Germany (1,284), Great Britain (743), Austria (637), the Netherlands (417), Sweden (415) and France (367) sent the most students, and Sweden (1,305), Germany (1,019), Great Britain (774), the Netherlands (354), Austria (337), France (336) and Finland (304) received the greatest numbers. There was a large increase in the exchange between the United States and other countries (131 compared with 59 in 1956) and also in the exchanges of Canada, the Netherlands, Spain and Turkey. The Union of South Africa joined the organization as an associate member in January 1956. The annual conference was held at Trondheim, January 16–20, 1956, when the Advisory Committee was asked to examine the possibility of improving training programmes in industry and also to investigate the possibility of establishing a fund to assist necessitous students with their travel expenses. In some countries students participating in the exchange already have the advantage of reduced railway fares, and considerable progress has been made in the exemption from income tax of payments to students by the establishment of reciprocal agreements between certain Foreign Offices. Mr. R. A. Beijer, Svenska Industrins Praktiknämnd,

has succeeded Mr. J. Newby, of the Imperial College of Science and Technology, as general secretary, and the report includes a warm tribute to Mr. Newby's work. The annual conference in 1957 will take place in Aachen, January 14–17.

Industrial Information Overseas

UNDER the title "Telling Industry's Story Overseas" (pp. iv+61; 3*s.* 6*d.*), the Publicity Committee of the Federation of British Industries has issued a guide to the channels available for distributing industrial information overseas. The first chapter describes the final outlets—newspapers, magazines, periodicals, broadcasting agencies, films—through which a story can reach the public, or a particular section of the public, in overseas markets. In the second chapter the various channels of communication through which a story can be distributed and fed into these final outlets are described, while in the third, practical hints are given on how to use these channels. Appendixes list journals published in Great Britain mainly or exclusively for overseas; B.B.C. external regional services; world television services; and the names and addresses of the Central Office of Information's Chief Regional Officers.

"British Rainfall, 1954"

1954 was the wettest year over Great Britain as a whole since 1903. Over a large part of the country the fall was 140 per cent of the average. This was due not so much to the wet summer as to the fact that an unusually rainy summer was followed by an even more unusually rainy autumn. Though the summer rain impressed the public more, probably, than that of the autumn, it was by no means record-breaking. In both 1912 and 1879 nearly half as much rain again (15·9 and 15·7 in., respectively) fell in the three months June to August as fell in 1954 (11·6 in.). The 1954 average for the whole country was 39·1 in. compared with a normal (1881–1915) of 32·67 in. Only the Thames Estuary, by a few per cent, had less than the normal. The nature of the summer of 1954, with its succession of major depressions giving long periods of continuous moderate rain, is reflected in the comparative absence of heavy falls in short periods associated with thunderstorms. April 1954 was an exceedingly dry month, in which two stations in Devonshire had only 0·01 in., and the fall was less than 25 per cent over much of the country. Among other information in "British Rainfall, 1954" (Meteorological Office, London: H.M. Stationery Office, 1956. 25*s.* net) we learn that the organization of instruments for the recording at Cardington, Bedford, of rainfall variations over a small area reached an advanced stage. In this work, sixteen synchronized recording rain-gauges distributed over an area of four square miles will provide a detailed and accurate analysis of the spatial distribution of heavy falls of rain which will be of especial value in the design of surface water drainage systems as well as being of general meteorological interest.

International Committee for Bird Preservation

THE first meeting of the International Committee for Bird Preservation to take place in the continent of Africa will be in Bulawayo this year, when the Central and South African Conference will be held during July 8–11, followed by an excursion through the Wankie Game Reserve. Inquiries should be addressed to the secretary, Miss P. Barclay-Smith, British Museum (Natural History), London, S.W.7.

The Federation of Rhodesia and Nyasaland is the latest country to form a National Section of the International Committee for Bird Preservation, thereby bringing the total up to forty-five. The membership of the National Section of Rhodesia and Nyasaland is composed of the National Museums of Southern Rhodesia, the Department of National Parks, Game and Tsetse Control Department, Natural Resources Board, Natural and Historical Monuments Commission, Southern Rhodesia Game Department, National Hunters and Game Preservation Association and the Rhodesian Ornithological Society.

Forest Research in Canada

THE recognition in Canada of the great destruction of its forests and the wasteful utilization, with the realization that the forests were not inexhaustible, has resulted in a great swing towards conservation with a growing interest in forestry research in all its branches. In a recent publication of the Forestry Branch of the Department of Northern Affairs and National Resources, entitled "Research Work of the Forestry Branch" (Misc. Pub. No. 6; Ottawa, 1956), it is stated that research into the many phases of forestry and forest utilization is now carried out by a number of governmental, university and industrial agencies within a fairly definite pattern and with little duplication of effort; the latter a most important point. This is an important small publication, since it deals with both the forests and forest research situations in Canada and the organization of the Forestry Branch. It outlines the history of forest research and organization of the Research Division and its functions, and of forest policy. Forest products research is dealt with separately as this has more specially reference to industrial requirements. Finally, forest economics are glanced at.

Forest Products Statistics of the World

THE ninth "Year Book of Forest Products Statistics", prepared by the Forestry Division of the United Nations Food and Agriculture Organization, contains information gathered from more than a hundred and twenty countries for 1954, together with revised data for 1953. The tenth anniversary of the Organization occurred last year, and the work of the decade has been devoted to improving the standard of international forestry and forest products statistics. The latest year book is more complete and accurate for more countries than its predecessors. Good statistical information is considered to be the base of good forestry, and programmes for this purpose are being started and improved under the auspices of the Organization.

Films on Parasitology

AT a congress of the International Scientific Film Association which met in Brussels in 1949, it was decided to collect information about films dealing with human and comparative parasitology. The work was begun by Prof. Rodolfo V. Talice of the University of the Eastern Republic of Uruguay and was later published. A third edition of the list of films has now been published and contains information about 260 films from nineteen countries. Britain is well represented; but, not surprisingly, the United States contributes more than any other country; the number from the U.S.S.R. is disappointingly few. The films are grouped under the heading of general

parasitology, epidemiology; insecticides, vermifuges, and antimalarial drugs; rickettsia; and animal parasites, and are clearly set out and described. Further information about the list, which contains English translations of the French text, may be obtained from W. de Vogel, Catharijnesingel 59, ingang Sterrenbos, Utrecht, Holland.

A New Core-sampler

An almost unexplored record of the Earth's history is preserved in the sediment under the great oceans. Profiles of the uppermost layers have been obtained by many different types of corer, and to this list Prof. B. Kullenberg has now added a modified version of his elegant piston corer which should reach deeper than ever before (*Meddelanden från Oceanografiska Institutet, Göteborg*, 26, 1955. Göteborgs Kungl. Vetenskaps–och Vitterhets–Samhälles Handlingar. Sjätte Foljder Ser. B, 6, No. 15). The new corer carries the same weight as the old model, 1,500 kgm., but has greater penetrating power, because with a length of only 2·3 metres there is a relatively small area of wall in frictional contact with the sediment. With such a design the driving weight must enter the sediment and so the weight encases the tube and is shaped to cause minimum drag. The corer sinks down through the sediment to a depth determined by the length of cable wrapped around its upper end. When all this cable has been unwound, the piston, which up to now has been locked at the lower end of the corer, is released and a core is taken. Although this ingenious corer has reached down to 29 m. and is expected to reach 50 m. in soft sediment, it is only suited to giving 'spot' samples, and so there still remains the ultimate problem of how to reach and take a continuous profile of sediment which can be a full kilometre thick.

Physics of Nuclear Fission

A symposium on the physics of fission was held at Chalk River, Ontario, Canada, in May 1956, and a detailed account of the proceedings has been published as a report by Atomic Energy of Canada, Ltd. (AECL No. 329, pp. 414; 5 dollars). The twenty papers presented are in the nature of authoritative reviews of the present state of knowledge, rather than reports of original research, since the symposium had a mainly educational purpose. An introductory section outlines the experimental results of low-energy and high-energy fission ('low-energy' and 'high-energy' here refer to the excitation energy of a nucleus before fission, the dividing line being at roughly 20 MeV.), and the discrepancies between observation and the predictions which can be made on the basis of the liquid drop nuclear model. Subsequent sections deal with the probability of fission (including spontaneous fission and photofission), the detailed experimental results, and the theoretical aspects. A summary of the spirited discussion which took place is given at the end of each section, and many diagrams and references are also given. The report is an excellent and comprehensive survey of the experimental results of fission physics and the extent to which they can be interpreted on current nuclear theories, and gives well-informed views on the directions in which future work may develop. It is stated that a classified supplement has been prepared; but it is unlikely that physicists interested in the fundamentals of nuclear fission will be frustrated by the requirements of secrecy, which nowadays cover a rather small area.

Spring Strips

Spring strips made of tempered steel or other elastic materials are used extensively in the construction of many types of measuring instruments. Flexible couplings, pivots, simple means of obtaining parallel motion, and the magnification of small movements are among their more common applications, and their particular advantages are freedom from friction, play and wear, and the absence of lubrication. Instrument design may often be considerably simplified and the cost of manufacture reduced by using spring strips, and in order to assist designers and provide them with a knowledge of the general principles of function of some of the more useful arrangements of spring strips the National Physical Laboratory, Teddington, has recently published Notes on Applied Science, No. 15, "Applications of Spring Strips to Instrument Design" (H.M. Stationery Office, 1956; 2*s*. net). In its various sections, single-strip pivots, cross-spring pivots, parallel motion, conversion of linear into angular motion, buckling strips and twisted spring strips are dealt with, and both theoretical and numerical data are quoted together with suitable applications of the mechanisms. In the final section a brief discussion is given of methods of attaching spring strips to related parts of instrument mechanisms, the most common method being the use of clamping plates. The text of the booklet is adequately illustrated by clearly-drawn line drawings and graphs.

Solar Deflexion of Light

The deflexion of starlight by the gravitational field of the Sun forms one of the three well-known tests of the theory of relativity. Einstein's theory predicts that a ray of light passing close to the Sun will be deflected through an angle twice that predicted by Newtonian mechanics. While the relativistic effect has been discussed in print on many occasions, it is rare to find a text-book which treats the problem by means of Newtonian mechanics. Teachers and students will therefore be glad to have such a treatment available, and Dr. M. Davidson (*J. Brit. Astro. Assoc.*, 66, 268; July 1956) has provided one, deriving the result from first principles without even the use of the usual formulæ of dynamical astronomy; the use of the latter formulæ would provide a still shorter derivation.

Publication of Lectures in Biochemistry

When possible, the Biochemistry Department, University College, London, intends to publish the public lectures given in the Department by invited lecturers. The first instalment covers the year 1954–55 and contains lectures on the catalytic activity of vitamin B_6 by E. E. Snell (Texas), on the respiratory mechanisms in bacteria by S. R. Elsden (Sheffield), and on metal complexes and metallo-enzymes by R. J. P. Williams (Oxford). A full report of a colloquium on biochemical aspects of chelation is also included. These public lectures were anything but 'popular', but it is good to have them made available to a wider circle of specialists. The distributing agents are Messrs. H. K. Lewis, London.

Handbook of Magnesium-Organic Compounds

"A Handbook of Magnesium-Organic Compounds", by S. T. Yoffe and A. N. Nesmeyanov (in three volumes, with a foreword by Prof. W. Wardlaw, translations and notes by Dr. A. L. Mackay. Pergamon Press, London and New York, 1956; £24,

or 72 dollars the set), recently published, lists 13,395 reactions, which are indexed by magnesium-organic compound used, by starting material, by end product, and by author. The list was compiled principally from the *Chemisches Zentralblatt* from 1899 to 1940 and from *Chemical Abstracts* from 1941 to 1948, and supplements are planned to maintain this work as a standard contemporary source of reference. The nomenclature confirmed by the International Commission on the terminology of organic compounds held at Liège in 1930 is used. References to non-Russian literature are in the Latin script, but sources in the Russian language are quoted in the Cyrillic alphabet.

Nuclear Data Cards

THE National Academy of Sciences, National Research Council, announces that the large number of subscriptions to the monthly card sets prepared by the Nuclear Data Group has enabled them to be issued at a substantially reduced cost. The price to subscribers during 1957 will be: in the United States and Canada, 15 dollars (first-class mail); elsewhere, 15 dollars (printed matter rate) or 19 dollars (first-class mail); air-mail subscriptions for Europe will be about 30 dollars, and for Japan about 45 dollars per year.

International Congress of Crop Protection

THE fourth International Congress of Crop Protection will be held in Hamburg during September 8–15, when the following subjects will be discussed: fundamental research (diseases, causal agents, pests), phytotherapy, protection of stored products, crop protection techniques, plant quarantine, organization and legal regulations. Visitors to the Congress are asked to give the titles of papers they wish to deliver before April 1, to the Biologische Bundesanstalt für Land- und Forstwirtschaft, Messeweg 11/12, Braunschweig, from which further information can be obtained.

University of London

THE following appointments in the University of London are announced: Prof. D. H. R. Barton, regius professor of chemistry in the University of Glasgow, to the university chair of organic chemistry tenable at the Imperial College (see *Nature*, **175**, 194; 1955); Dr. E. Neil, reader in physiology at the Middlesex Hospital Medical School, to the John Astor Chair of Physiology tenable at that School; Dr. Cyril Dodd, lecturer in physics at University College, to the university readership in physics tenable at that College. The title of reader in chemistry in the University of London has been conferred on Dr. P. B. D. de la Mare, in respect of his post at University College; and that of reader in pharmacology in the University of London has been conferred on Dr. J. A. Nissim, in respect of his post at Guy's Hospital Medical School.

Announcements

SUBRAHMANYAN CHANDRASEKHAR, distinguished service professor of theoretical astrophysics in the University of Chicago, has been awarded the 1957 biennial Rumford Premium of the American Academy of Arts and Sciences, "for extending to the cosmic realm the stochastic laws which, on the atomic scale, govern the phenomena of heat; and for his monumental work, 'On the Radiative Equilibrium of a Stellar Atmosphere', in which heat is transported as light, and light supports matter, and matter is ultimately the source of heat itself".

DR. W. J. WORBOYS has been awarded the Medal of the Society of Chemical Industry, which is awarded not more than once every two years for conspicuous services to applied chemistry or to the Society. Dr. Worboys has been a director of Imperial Chemical Industries, Ltd., since 1948.

Dr. D. C. Moore and Mr. E. A. Taylor, of Imperial Chemical Industries, Ltd., have been awarded the Sir William J. Larke Medal for 1956 by the Institute of Welding for their paper on "The Welding of Copper and Copper Alloys", being the paper judged of the highest merit among those presented to the Institute during the year.

MR. J. F. RICHARDSON has been appointed technical secretary of the Radio Communication and Electronic Engineering Association, under Mr. H. E. F. Taylor, who was recently appointed executive secretary of the Association.

COLONEL B. A. AUSTIN has been appointed chief engineer to Isotope Developments, Ltd. Prior to his service in the Army, Colonel Austin was with Vickers-Armstrong, Ltd., engaged on design and development of computing gear and artillery fire control equipment.

MR. H. F. TREMLETT has been appointed deputy director to the British Welding Research Association at its Research Station at Abington. Mr. Tremlett, who graduated at the Royal School of Mines in 1932, was head of the welding section, central research organization of the Siemens Melting Department at Samuel Fox and Co.

MR. E. A. POULTON has been appointed director of aircraft mechanical engineering equipment research and development in the Ministry of Supply in succession to Mr. R. Graham, who has retired.

AN international convention on starch, organized by the West German Cereals Research Association, will be held at Detmold, Germany, during April 24–26. It will comprise three sessions as follows: research and analysis; starch manufacture and industry; starch fractions and derivatives. Further information can be obtained from the Arbeitsgemeinschaft Getreideforschung e.V., Detmold.

THE Aeronautical Engineering Department of the University of Southampton is to hold a course on acoustics during April 1–6. The course is designed for those having no preliminary knowledge of acoustics, and is intended chiefly for workers in the aeronautical industry, and elsewhere, who have to deal with the increasingly important problems of noise. Further details may be obtained from Mr. D. J. Mead, Aeronautical Engineering Department, The University, Southampton. Applications should be made before March 1.

THREE postgraduate fellowships for those wishing to pursue advanced courses on research in the earth sciences, with especial application to oceanography, have been established by funds from the Associates of the Woods Hole Oceanographic Institution. The fellowships, which are tenable at any approved college or university, will carry a stipend of 2,500 dollars per annum for a single man, or 3,000 dollars per annum for a married man. Application should be made before February 1 to the Director, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, U.S.A.

EDUCATION AND TRAINING OF THE CHEMIST

A CONFERENCE attended by about 250 chemists which was called by the Royal Institute of Chemistry to consider "The Education and Training of the Chemist" was held in the William Beveridge Hall, the Senate House, University of London, on the afternoon and evening of October 26. The president of the Institute, Dr. D. W. Kent-Jones, welcomed the company, especially the many visitors representing a great variety of educational and technical organizations and employing bodies. He expressed his pleasure that Sir Ian Heilbron, who had much experience of the subject for discussion, had been able to accept the Council's invitation to preside at the opening session. Another distinguished chemist, Prof. J. W. Cook, took the chair for the evening session.

Sir Ian Heilbron said that the conference was timely in view of the national demand for an increase in the annual output of scientists. He stressed the need for avoiding the "relentless creation of a nation of specialists".

The five invited speakers, Dr. Norman Booth (industry), Sir Owen Wansbrough-Jones (government service), Prof. E. G. Cox (universities), Dr. E. G. Edwards (technical colleges), and Sir Eric James (schools), briefly presented their opening papers. These contributions have been published in full in the September issue of the *Journal* of the Institute. They covered a wide field and the discussion ranged over it. Difference in outlook mainly between the industrial and university representatives was manifest; the opinions of the industrial group were not always urbanely expressed.

There were a number of criticisms of the university efforts. It was suggested that academic staffs were recruited for their research rather than for their teaching abilities so that their interests lay mainly with the few brilliant "alpha men", who would eventually teach in a university. The good "solid beta man" destined for industry got rather step-motherly treatment.

The normal honours course found little favour. It was said that it put a premium on the ability to carry abstract concepts in the mind for a prolonged period with little contact with their application. One speaker called for its disembowelment, and its present high content of odd and unimportant facts replaced by a logical sequence of fundamental principles which the student should be trained to use in his thinking. The lecture system was criticized and voluminous note-taking at high speed deprecated.

But if the course was bad, the product was worse. Industry definitely does not want the brilliant highly trained specialist, who has come to the much-talked-of frontiers of knowledge, passed through the sense-barrier, and toppled into the abyss beyond. Brilliant scholars with breadth of knowledge are often extremely difficult in a works. Intellectual cream concentrated in one place tends to turn sour. Men with a sound grounding in chemical principles who have been trained to think are required in large numbers. The conference was also told that there is more than a small gap, there is a howling wilderness between the product of a university and the requirements of industry. Many fresh graduates coming out of universities looked and no doubt felt like fish out of water when they entered a factory; they were unable to tackle the simplest matter without detailed instructions.

Experience in government departments differed radically from that in industry. The State authorities were in the main satisfied with the graduates they recruited and with the training these had received. The university grading was generally confirmed.

The industrial representatives placed great stress on the principle that the foreman should be able to knock out any man of his gang. One university product mildly but rashly suggested that, admitting the importance of practical training, it was perhaps a waste of time to teach a student to carry out analytical work with an accuracy approaching that of a routine analyst. He thought that a chemist in charge of technicians need not be able to carry out each of the operations he supervised better than the expert—"a man who drives fat oxen need not himself be fat". This tentative view was regarded as "nonsense" and "a shocking thought". Indeed it was considered that university students and examiners attach too little importance to practical examinations when they exist. The young alpha graduate entering industry is somewhat delta when given a job at the bench.

The proposal that with the growth of fundamental knowledge it would eventually be necessary to add a year to the honours course found little favour. There was, however, a ready market for a suggestion which involved the replacement of the present final year by one in which the student was shown how practical problems are tackled and given practice in tackling them. Some considered that the training of a chemist should include an introduction to such subjects as applied electricity, fluid flow, unit operations of chemical engineering, and fuel technology.

On the academic side it was stressed that the universities would not entertain any considerable alteration in the type of work they were doing despite considerable pressure from without. All present were agreed that a chemist should be educated so that he would be a life-long student, who, apart from his training, would have acquired habits of study and be able to teach himself. The differences in opinion manifested in the conference were in relation to training rather than to education. The academicians held that practical skill was not sufficient to justify admission to the profession of chemistry—intellectual capacity must be the criterion for the award of honours. In this connexion the possibility was canvassed that some of the difficulties of industrialists with chemistry graduates arose from a tendency to employ chemists on routine practical operations proper to technicians.

It was admitted, however, that the university course could be streamlined so as to avoid overlapping and repetition. There was at times too great an emphasis on factual knowledge, for example, in the study of natural products and certain sections of inorganic chemistry. It was possible that there was undue concentration on research with lessened

interest in teaching in modern departments of chemistry.

The proposal to have a final 'applied' year for an honours degree was rejected by the university representatives. They pointed out that students should study a full applied or a full academic course. Doubt was expressed about the intellectual content of the proposed applied year. A man taking it would be committed to applied chemistry as a career and would lose the freedom of choice that an honours graduate now received from his all-round basic training in chemistry. Further, the normal final year is essential to round off the work of the previous years. The present course is not too long by comparison with continental practice or with that of twenty years ago when there was so much less ground to be covered.

For the rest, the conference discussed with rather less tension a number of topics of interest, among them the teaching of science in schools. The point was made that so far as possible modern knowledge should be fed back to school classes and an effort made to introduce electronic theory at an early stage. Generally the lack of trained laboratory technicians was a stumbling block alike to the efficient presentation of chemistry and to the recruitment of teachers. Otherwise there was an optimistic note about science teaching in boys' schools. The position in girls' schools left more to be desired. Stress was laid on the possibility of increasing the supply of chemists by a wider recruitment of women. However, it was mentioned that their susceptibility to matrimony involves their frequent untimely removal from the profession.

Mathematics and physics were regarded as first-choice ancillary subjects for the chemistry degree. But most of all the necessity for a thorough grounding in the English language was stressed. Precision and clarity so essential in discussing science depend on skill in manipulating language. The ability to think is largely dependent on the ability to use language. It was not thought that with the present overloading of the courses in chemistry the student could find much time for the study of cultural subjects. These must be left to his home and school environment.

The importance of technical colleges in training a large number of students who otherwise would have no opportunity of receiving professional qualifications in chemistry was recognized. There was support for the view that it is wasteful for a young student of ability to have to undertake a chemical education solely through evening classes. Transfer to full-time or sandwich courses was recommended. It appeared, however, that it is often more awkward for chemical than for engineering firms to fit in with sandwich courses. The difficulties of students from technical colleges who frequently have to sit externally assessed examinations, such as those of the Royal Institute of Chemistry, with no published syllabus was mentioned. Both teachers and students should have a reasonably precise statement of the course to be covered and should not have to depend on previous papers.

To return to the main issue, the impression gained was that some industrialists resemble patients, who could not care less whether their doctor has studied the premedical and preclinical sciences, if he can treat the common diseases and recognize an acute state needing hospitalization. Similarly, the employers require their chemists to have merely the theoretical knowledge and practical skill adequate to the duties assigned. It matters little if a professional chemical employee cannot recognize a lone pair of electrons if he sees one, or thinks an axial bond relates to pre-war diplomacy—provided his duties do not require a knowledge of these concepts. In this respect the industrialists follow the great Locke, who wrote in 1693: "Could it be believed . . . that a child should be forced to learn the rudiments of a language, which he is never to use in the course of life that he is designed to, and neglect all the while the writing of a good hand, and casting of accounts". The universities, of course, hold with Newman that science should be studied as a discipline and that general culture of the mind is the best aid to professional and scientific study. They reject the criterion that utility should be the basis of what is taught. They do not seek to train students to be professional practitioners, but rather to educate them so that eventually they become professional men of full stature. How to continue to accomplish these aims and also to modify the courses to satisfy the employers, if indeed this is desirable, remains for the future to solve.

T. S. Wheeler

PHYSICS OF LIQUID HELIUM

ORAL discussion between scientists who are unable to visit each other easily is commonly brought about by means of large-scale conferences. In the case of low-temperature physics, for example, international conferences are held at two-yearly intervals. They are attended by perhaps two hundred and fifty people and usually cover about eight more or less separate subjects. The high cost of travel to foreign countries, and the limited size of the conferences compared with the number of people actually engaged in the work, make it difficult or impossible for a young research worker to attend these meetings except when they take place in his own country. Moreover, when he is able to attend, he finds the atmosphere generally formal and indeed on occasion somewhat competitive, and the amount of time available for discussion is in any event strictly limited.

The Low Temperature Committee of the Physical Society, under the chairmanship of Dr. K. Mendelssohn, therefore considered that there is a place for occasional smaller meetings, in which it would be possible for young research workers as well as others directly interested to discuss informally the subject of their research. In order to provide for this, a series of one-day discussion meetings has been initiated, the first of which, on the subject of liquid helium, was held on November 2 at the Institute of Physics, and attended by about forty people. While it was not intended that the meeting should be an international one, it was thought that the discussion would benefit from a report on recent work in Leyden, and an invitation was sent to one research worker from the Kamerlingh Onnes Laboratory. The principal aim of the meeting was to allow adequate time for discussion of the work: the contributors were therefore asked to restrict the length of their papers to about ten minutes, and a rather longer time than this was allowed for discussion of each paper.

With a meeting of this kind, which is intended to be informal, it is neither possible nor desirable to make a full record of the individual contributions to the discussion. In the following report I have therefore summarized as completely as space allows

the main points brought out in papers and discussions together, without attempting to separate the two. I have been greatly assisted in writing this by Dr. E. Mendoza and Messrs. L. J. Challis, L. Grimes, M. J. White and R. W. Whitworth, who made notes of the proceedings.

The opening of the meeting was overshadowed by the very recent death of Sir Francis Simon. A tribute was paid to him by Dr. K. Mendelssohn, who has been associated with him for thirty years, and the meeting stood for a few moments in silence in his memory.

In the first paper, Mr. O. V. Lounasmaa (Oxford, on leave from Turku University, Finland) described recent measurements of the specific heat of liquid helium, carried out at Oxford in collaboration with Dr. R. W. Hill. These experiments, which cover the range from 1·8° K. to the critical point under the saturation vapour pressure, are particularly interesting for two reasons. In the first place, the measurements below the lambda-point finally resolve the discrepancy which has existed for some time between earlier results obtained in Oxford and in Leyden, since they agree closely with the Leyden results. It is unfortunate that the reason for the error in the earlier Oxford results is unknown, since it is still impossible to assess with certainty any error which may be present in the results at higher densities which were obtained at the same time. In the second place, the specific heat above the lambda-point is now known with much more accuracy than hitherto. This is especially important in view of the present discussions on the helium temperature scales, since the scale of van Dijk and Durieux makes use of these data. The new results agree fairly well with the previously available data of Keesom and Clusius, and so it is not to be expected that any great change will ensue in this scale; but the considerably increased accuracy and number of the measurements will give more certainty than it possessed before, and make possible a more realistic comparison with the American experimental scale.

Observations on the osmotic pressure of helium-3/helium-4 mixtures were discussed in contributions from Dr. H. London (Atomic Energy Research Establishment, Harwell) and Mr. Wansink (Kamerlingh Onnes Laboratory, Leyden). In Dr. London's experiments, which were performed with Dr. E. Mendoza (H. H. Wills Physical Laboratory, Bristol), a helium-3/helium-4 solution is made to communicate with pure liquid helium-4 through a superleak, and the temperatures of the two liquids adjusted until their fountain pressures balance, with no net flow of liquid through the superleak. The difference between the measured fountain pressure and the fountain pressure of pure helium-4 (calculated from the temperature difference across the superleak) gives the osmotic pressure of helium-3. At helium-3 concentrations X from 0·019 to 0·023, and for temperatures between 1·0° K. and 1·7° K., the osmotic pressure is found to have approximately the value one would expect for helium-3 in perfect solution, namely, $\pi = -\frac{RT}{V_{\text{mol.}}} \ln [(1 - X)f_4]$ with the activity coefficient f_4, which indicates departure from ideality, equal to unity. At higher concentrations of 0·14–0·16, the osmotic pressure is less than this, so that $f_4 > 1$; but the results are not yet accurate enough to give more detail. These experiments extend the temperature range of some measurements already made in Leyden, using a similar technique, and Mr. Wansink described further results which again follow the same equation with $f_4 > 1$. Values of f_4 can also be calculated from the vapour pressure, and in this way a corrected vapour pressure versus concentration relation has been constructed at 1·2° K., replacing previous unreliable results. Some discussion took place concerning the possibility of cavitation in the slit due to complete sucking out of the liquid to the warmer side, which was encountered in London's experiments, but apparently not in Leyden. It was suggested that this might be due to a slightly different experimental arrangement, but no satisfactory reason emerged.

Theoretical contributions to the meeting were made by Mr. H. N. V. Temperley (Atomic Weapons Research Establishment, Aldermaston), Dr. R. K. Eisenschitz (Queen Mary College, London) and Dr. C. G. Kuper (St. Andrews). Mr. Temperley discussed recent treatments of liquid helium based directly on the many-atom Hamiltonian. He began by reviewing the considerable achievements of the two-fluid picture which, although in the first place a purely phenomenological model, was later shown to follow from an energy spectrum involving two kinds of excitations. Landau was led to such an energy spectrum, which could also correlate certain other phenomena in helium-3 and helium-4, through the quantization of the equations of hydrodynamics, but it is uncertain whether this is consistent with the Hamiltonian. More recently, attempts have been made to derive the two-fold spectrum directly from the Hamiltonian, either by means of a transformation of wave-functions (Bijl, Feynman) or of co-ordinates; in the latter case one can use either a solid-like approach (Debye–Peierls) or a plasma-like approach (Bohm–Pines, Tomonaga, Zubarev, Brenig, Bogolyubov and others). In all cases the difficulty is to ensure that the correct boundary conditions are obeyed. Dr. R. Eisenschitz dealt with various aspects of the phonon representation as put forward by Zubarev and Bogolyubov, and having applied this representation to the flow of momentum and energy as derived from the principles of quantum mechanics, concluded that the naïve picture of phonons carrying momentum and energy is of limited validity. A more stringent test of the theory could be made by evaluating the Russian authors' expression for the velocity of sound; so far, only an elementary estimate of its upper limit has been made, but more accurate calculations are in progress.

The possible importance of surface excitations in determining the behaviour of helium II was pointed out by Dr. Kuper. Landau showed that a massive body moving in liquid helium II at less than a certain velocity could not create excitations and so would suffer no retardation. Considering only volume excitations (phonons and rotons), these critical velocities were estimated to be of the order of 10^4 cm./sec., whereas experimentally they are found to be only a few centimetres per second. For a surface wave on a deep liquid, on the other hand, the critical velocity for the creation of 'ripplons' turns out to be about 10 cm./sec., and although in the bulk liquid the small values of critical velocity are probably due to the effect suggested by Feynman —the creation of vortex lines—these surface excitations might be the determining factor in the case of the film. One might also expect them to form an appreciable part of the normal fluid in the unsaturated film, thus lowering its temperature of onset

of superfluidity, as observed. However, this lowering of the onset of superfluidity is also found in the flow of 'bulk' liquid helium through channels narrower than the film thickness, and it is not clear how the theory would apply in this case where there is no free surface. Experiments on the flow of helium through such narrow channels were actually described later in the day by Mr. D. C. Champeney (Clarendon Laboratory, Oxford). The average width of the channels was about 50 A. (that is, approximately half the saturated film thickness), and the onset temperature agreed with the value for an unsaturated film of this thickness. An appreciable flow of liquid was found even above the depressed onset temperature, with no significant change at the normal lambda-point, the flow being proportional to the square root of the pressure head, that is, corresponding to turbulent flow in a classical liquid. In passing through the onset temperature, the flow-rate increased by a factor of more than 20,000 within 0·2 deg. K., and was still strongly dependent on pressure. With experiments such as these, the possibility occurs of dependence upon pressure in superflow due to the heat developed in the reservoir by the mechano-caloric effect. It seems that this possibility has been eliminated, since the deliberate introduction of additional heating makes no significant difference to the dependence on pressure.

During the past few years, much research has been done in Bristol on the formation and properties of the helium film, using the now well-known optical technique. The investigations there, as in other laboratories, have been mainly directed to deciding whether the film is formed by purely van der Waals adsorption or is due to some quantum mechanism. The purpose of the latest work, described by Dr. L. C. Jackson, is to see if the film formed from the saturated vapour has the same thickness and profile as when it is in contact with the liquid. The main problem in this experiment is to mount the mirror on which the film is formed in such a way that it receives no extraneous heat input which might evaporate the film, without contact with the liquid. This is solved in an ingenious way, by floating a magnet above a superconducting lead cup in the manner first described by Arkadiev, and suspending the mirror from the magnet by a fine thread. The method works surprisingly well, and there is a quite sufficient degree of stability. The results are so far only preliminary, but the thickness and profile of the film seem to be very similar to those when it is in contact with liquid.

Considerable progress towards the understanding of liquid helium has lately been made through Landau's theory of excitations and the Onsager–Feynman theory of quantized vortex lines, and the remaining papers presented to the meeting dealt with further experiments which could be described in terms of these theories. By consideration of the relaxation processes occurring in a phonon–roton gas, Landau and Khalatnikov have worked out theories of the absorption of sound, and of the normal fluid viscosity of liquid helium. Additional evidence of the essential correctness of these theories was presented by Dr. K. Dransfeld and Mr. D. O. Edwards (both of the Clarendon Laboratory, Oxford). The absorption of sound has been measured by Dransfeld, Newell and Wilks as a function of temperature, pressure and frequency. As the temperature is reduced from 2° K., the absorption rises to a maximum at about 0·9° K. and then falls off quite quickly. Above the maximum, the absorption is mainly due to Khalatnikov's process of second viscosity, whereas below the maximum this effect is negligible, the absorption being determined principally by heat conduction, which is dominant at the lower temperatures because of the long phonon mean free path. At the maximum itself both processes contribute in a complex manner, and it is difficult to decide the magnitude of each; but the variation of the height and position of the maximum with pressure and frequency agree qualitatively with Khalatnikov's theory. Extremely good agreement between experiment and the theory of Landau and Khalatnikov is also found in the viscosity experiments described by Edwards. These measurements are made not by the rotating cylinder method, but by measuring the sub-critical heat conduction in capillary tubes, which also yields the normal component viscosity. Values of the viscosity for tubes of diameter 0·05 mm. and 0·1 mm. suggest that it is necessary to make corrections for a phonon mean free path effect, and when this is done the results for both tubes fall on one curve, giving to within a few per cent the dependence on temperature predicted by theory between 1·15° K. and 1·7° K. The measurements agree very well in magnitude with rotating-cylinder viscometer values and it now seems safe to conclude that the divergence between these and the oscillating disk results is due to some defect in the latter measurements, probably the presence of unwanted heat flows. Experiments were also made at pressures up to about 30 atm., where the main effects are large positive dependence on pressure at temperatures above about 1·8° K., and small dependence on pressure at lower temperatures.

For the purpose of the viscosity measurements, the heat flow in these experiments is kept to such a low value that the superfluid experiences no frictional forces and the heat resistance is constant to a first approximation. Dr. D. F. Brewer (Clarendon Laboratory, Oxford) described the effects occurring when, using the same capillary tubes, the heat flow is increased. Above a certain critical velocity there is first a well-defined transition region where the resistance rises sharply, and then a region where the resistance increases more slowly. Over a restricted range of temperature and mutual velocity, the resistance increases with the fourth power of the mutual velocity for the narrowest tube, changing to an approximately third-power law for the widest tube (0·36 mm. diameter); many of the results cannot be described by a power law at all. Other curious effects are observed, such as extreme sensitivity to vibration, and pronounced hysteresis and time effects. These can be given a plausible explanation along the lines of the Onsager–Feynman theory, but it is unlikely that a quantitative explanation can be given owing to the small number of vortex lines involved, and the possible influence of the surface condition of the capillary tubes.

On the other hand, a quantitative theory can be given when there is a large number of vortex lines and the influence of the neighbouring surfaces is negligible. Dr. W. F. Vinen (Royal Society Mond Laboratory, Cambridge) has performed experiments on the propagation of second sound in uniformly rotating helium II, which gave a marked excess attenuation dependent on the direction of propagation and the axis of rotation. Detailed interpretation in terms of the two-fluid model indicate a mutual friction proportional to the product of

the angular velocity of rotation and the mutual velocity, and dependent on the angle between them. Previous heat-conduction measurements in wide tubes had given a third-power mutual friction of the Gorter–Mellink type associated with turbulence in the superfluid, and it was suggested that this turbulence took the form of a confused tangle of vortex lines, mutual friction being due to collisions between normal fluid excitations and the vortex lines. A calculation based on this mechanism leads to a cubic mutual friction of the right order of magnitude with a collision diameter for roton–vortex line collisions of about 10 A., but a number of difficulties arise in attempting to derive a complete theory. It now appears that different results obtained at Yale with a similar experiment can be reconciled with the present observations.

The theory of vortex lines is again used in explaining the results of experiments by Dr. H. E. Hall (Cambridge), in which measurements are made of the forces producing angular acceleration and retardation of helium II contained between closely spaced disks. For an angular velocity of 1 rad./sec. the amount of angular momentum collected on stopping the rotation has the full classical value, but for smaller angular velocities it falls progressively below this, the missing angular momentum corresponding to a persistent current which is probably irrotational and has a lifetime of more than 0·25 hr. The simplest mechanism for the generation of such persistent currents is the removal of vortex lines by the Magnus effect, but the actual mechanism is probably more complicated. Comparison of the frictional forces observed using spacers of different diameters between the disks suggests that at an early stage in the retardation process the superfluid becomes turbulent with an irrotational mean flow. At superfluid velocities less than a critical value turbulence decays on the disk surfaces and retardation stops.

Following the success of this first discussion day, plans are going forward for a second meeting, which will be concerned with low-temperature distillation, and will take place early in the present year.

D. F. Brewer

THE TEACHING OF METEOROLOGY IN SCHOOLS

In the past, the teaching of meteorology in British schools was largely a matter of climates and trade winds, with but little study of the actual weather outside the windows or much relevance to the future lives of most of the pupils. The October 1956 number of the Royal Meteorological Society's magazine *Weather*, which has the teaching of meteorology as its main theme, gives evidence of the coming of a more vivid, physical and realistic approach.

A group of H.M. Inspectors of Schools contribute the main article, "Meteorology in Secondary Schools", which deals with the reasons for studying physical meteorology as well as geographical climatology in schools and provides an outline course of study. The group points out that the weather may be of vital importance to some pupils after they have left school and will at least be of interest to all. Apart from future use of knowledge of the processes of weather, study of them provides illustrations of important physical principles and, in simple observing work, an introduction to scientific accuracy and method. The outline course opens with the basic physics of radiation, condensation, relation of wind to pressure, etc., and goes on to properties of air masses and fronts and methods of observation. It is stressed that the teacher should correlate his lesson on air-masses by reference to the weather of the day but does not mention the interpretation of the broadcast forecasts. The latter is the most obvious omission in the course and is regrettable because weather forecasts will be used to greater or lesser degree by all the pupils in adult life. An amusing note is provided by the examples of awkward questions which pupils might ask on matters not understandable without more advanced physics or mathematics.

Mr. J. B. Rigg describes the meteorological studies at Watford Grammar School. These begin at the age of 11 years with the making of simple rain-gauges. In the sixth form the geography students, who include many also taking physics and mathematics, carry out much practical work with the comprehensive collection of instruments.

A number of publications, such as the "Observer's Handbook", are mentioned in the articles. Reference might also have been made to the Ministry of Agriculture pamphlet, "Weather and the Land", written by the Agriculture Branch of the Meteorological Office, which gives admirable guidance in the interpretation of the broadcast weather forecasts to meet local conditions.

An editorial discusses whether it is likely to be possible to teach any of the more recently gained knowledge in meteorology in sixth forms. It considers that there is a great opportunity for physics teachers to show the operation of basic physics in the weather, but little possibility of modern dynamical meteorology being taught because in their honours courses most mathematics teachers have not learnt real hydrodynamics with vorticity and viscosity.

UNUSUAL UPPER-AIR REFRACTION PHENOMENON

The optical phenomenon of 'looming' which occurs when the air temperature increases very markedly with height is well known at low altitudes, especially in the polar regions. The rays of light from distant objects are then much more strongly curved in an arc convex upwards than usual, so that distant objects are apparently raised and multiple images successively upright and inverted are seen. This is the effect opposite to the mirage associated with a very steep fall of temperature with height, in which the rays become convex downwards and the sky is seen on looking along the ground.

The August number of the *Meteorological Magazine* contains an account by C. S. Durst, G. A. Bull and E. J. Sumner of 'looming' of distant clouds seen from a Canberra aircraft of the Royal Air Force flying north-east at 45,000 ft. some 200 miles off the west coast of Norway at lat. 66° 20′ N., long. 2° 30′ E., at midday on November 29, 1955. The crew, Flying Officers E. E. Kortens and F. P. Fraser, saw a cloud like a bowler hat protrude upwards above the cirrus cloud before and ahead of them. It expanded vertically and sideways. Then another cloud lump appeared at the top of the first one and also spread sideways and vertically. Next a mushroom-like top appeared and finally another lump on top of the

mushroom. They likened the effect to published photographs of atomic bomb explosions and considered it was larger than any thunder cloud they had ever seen. No estimate of the distance was possible. The colour was white at first, later turning yellow-orange. At this stage they had to turn southwards and could not look backwards.

In turning, they noticed the temperature changed by 6 deg. C. Investigation revealed that an upper-air temperature observation at Keflavik, Iceland, at 3 a.m. on the same day included an unusual increase of temperature (inversion) by 4 deg. C. between 43,500 and 45,000 ft., well in the stratosphere, and that the wind distribution was such that this inversion would have reached the position of the aircraft at the time of the observation. Further, cumulo-nimbus clouds (towering thunder clouds) were observed at stations on the north-west coast of Norway during the morning.

From this it is concluded that the aircraft flew through the inversion and that the abnormal refraction within the inversion produced the distorted vision of these distant clouds. Photographs very similar in appearance of the Bavarian Alps have been taken in known inversion conditions from a peak in the Black Forest. Few similar observations have been reported by aircraft crews, unless some so-called 'flying saucer' reports have such a phenomenon as their basis, and certainly none from so great a height.

The Meteorological Office would welcome additional aircraft reports, especially for the light they would throw on the existence of unusual thermal structure at great heights.

ORDINARY FAMILIES AND THE SOCIAL SERVICES

WITH the financial assistance of the Nuffield Foundation, Political and Economic Planning is undertaking an investigation into the impact of the social services in Britain upon ordinary families. A pilot survey has already been made, and, in view of the importance of the findings, PEP has decided to make these available before the main survey is completed*.

The original proposal for the inquiry grew out of the considerable amount of research already carried out by PEP on different aspects of social welfare policy. This indicated that the time had come when further assessment of the working of the different services would be helped by a survey aimed at collecting information on the attitude of consumers to the services and on the extent to which their needs are being satisfied or overlooked.

In order to make the group studied reasonably homogeneous, only families with children were included in the survey. The inquiry was made into conditions affecting ordinary families and did not concentrate upon families in special difficulties, even though such families may be heavy claimants on the social services.

The basic purpose of the inquiry was to throw light on the extent to which it is felt that the needs of ordinary families have been met as well as to provide information on the role of the social services in family life.

An early step in the inquiry was to consult social workers to discuss the occasions when the different social services were likely to be used by ordinary families. Preliminary interviews were then carried out with some families in which discussion was based upon the points which had been formulated by this means; but no formal questionnaire was used. The interviews were long and all the situations relevant to use of the social services were discussed, ranging from childbirth to care of the aged. These interviews provided case-study material and showed that it was possible to find out the kind of use made of these services by a particular family.

Increased concern for the interests of the family as a whole has been one of the features of social thought in recent years. Attention has been directed to gaps in the working of welfare services and to overlapping or division of function leading to inefficiency in action. In spite of the wide range of statutory services it is still possible for families to get into difficulties which threaten their stability. The PEP inquiry sought to find out whether families had had difficulty in using particular services or were conscious of occasions when they had needed help but had not obtained it.

The extension of the statutory social services in the post-war years has led to some concern lest people should be encouraged to seek help outside the family circle, with a consequent lessening of personal sense of responsibility. It is believed by some that people are now looked after from the cradle to the grave, and that the Welfare State is the final realization of the aims of social reformers. It is also believed that the community has gone too far in taking over responsibility formerly left to families and individuals; that the cost of the social services bears too hard upon certain sections of the population; and that the present system of universal benefits is not needed in conditions of full employment and a high standard of living. The inquiry hoped to find out how far these attitudes are reflected in the opinions of ordinary families.

For the pilot inquiry, the main need was to interview as quickly as possible a large enough number of families to be able to judge whether the information could be obtained and handled as planned. Certain areas were chosen for convenience of interviewing in three different London boroughs, and random calls were made and interviews carried out wherever there was a mother with children in the house available for interview. In all, ninety mothers have been interviewed so far, and two fathers. There have been very few refusals. Interviews all took at least an hour, and sometimes two.

So far the inquiry has been entirely exploratory. Questions have been asked to obtain the following information:

How do mothers regard the help they receive? Do they feel their families are helped a great deal or not very much? Of which parts of the social services are they most aware? Is there a Welfare State attitude? What form does it take? How does the feeling of different sections vary? Which are the most important services? With which do families and mothers have a lot of contact? What differences are there between different sections of the population in contact with the services? Which services are considered to have worked well? How do people view the amount of help given? To what extent is there failure to obtain any service needed and how does it arise? What difficulties are experienced? How have families managed in particular situations of difficulty?

* *Planning*, Vol. 22, No. 403 (8 October 1956): Ordinary Families and the Social Services—Piloting an Enquiry. Pp. 189–204. (London: Political and Economic Planning, 1956.) 2s. 6d.

What resources of help have they used ? What degree of difficulty do they consider they have had ? What problems do families face at the moment ? What services might be concerned ? Do some families have problems which might be relevant to more than one service ?

The inquiries showed that, while there were many peculiar impressions about the different kinds of social services and how they were paid for, on the whole people had a clear idea of how they were financed, what the benefits were, and appreciated them. To take a measure of the success of the services, mothers were asked what they thought of the help they had received when they had last had contact with each service. They were also asked more detailed questions about their experience of some services.

Comments on the help given by the doctor showed a high degree of appreciation and also indicated what kind of things appreciation was based on ; these were mainly connected with the personal attention given by the doctor. The general attitude towards treatment received at hospitals was also extremely favourable. There were, however, a few more critical comments, particularly in connexion with the out-patient service. Most of these were complaints about waiting, but some were about treatment ; others were about conditions in which the treatment was given.

Many of the families with children under five were using welfare centres, but some were not. Most mothers using the centres thought them very useful, but some comments of a different kind were made ; complaints were usually that the centre was too far from their homes. The maternity grant was generally regarded as useful although it was thought to have little relation to the expense of confinement. In some cases the wife had worked beforehand to prepare for the expenses of this occasion and to provide a supplement to the grant. The attitude towards home confinement allowance was rather the same.

Most of the families who had drawn sickness benefit had had to rely upon additional resources of some kind. The part played by the benefit itself in meeting the cost of the family when the breadwinner was ill does not seem to have been as great as is generally believed. Many cases were found where the money had been made up by the husband's firm. Extra sources of help mentioned were club money, savings, borrowed money, wife's earnings, and so on.

Very many of the families interviewed had tried at some time to get help with a housing problem, and many of them still had their names down on housing lists ; many had been unsuccessful. Some families had managed to help themselves, and this was remarked on somewhat ruefully since the chance of obtaining a council house had thereby been lost. Several families considered that housing was their chief problem.

As the mothers were shown each list of services they were asked whether they could remember any occasion when one or other of their family had needed a particular service but for some reason had not been able to get it. The information resulting from this question was considered together with answers to specific questions about how they had in fact managed when the mother was ill, for example, or when the father was at home from work, or some other crisis had occurred.

Most of the families had had to cope with situations when the mother was ill through confinement and had managed with the help of friends and relatives. In several cases the husband had stayed at home from work, either taking annual leave or taking time off.

One of the purposes of the design of the survey had been not only to ask about the use of the different social services, but also to get a picture of the range of problems which families were facing. Some of the families had problems which were relevant to more than one of the social services.

The purpose of the pilot survey was to show what kind of material could be collected, and how to collect it. It did not attempt to collect sufficient data to provide the answers to the questions posed. This will be the task of the main inquiry. It is proposed that a random sample of something like a thousand families with children should be interviewed in a particular area.

EXPERIMENTS IN GROUP CONFLICT

CONFLICT between groups is often rooted deep in personal, social, economic, religious and historical forces. Inter-group conflict and harmony is not a subject that lends itself easily to laboratory experiments, and in recent years there have been attempts to investigate the problem under controlled yet life-like conditions.

A series of experimental studies was begun by Muzafer Sherif and his colleagues in 1948 and are still continuing. What the limited experiments have so far shown is described in *The Scientific American* (November 1956).

It was decided to conduct the study with groups of an informal type, where group organization and attitudes would evolve naturally and spontaneously. For this purpose an isolated summer camp was chosen as a good experimental setting ; and boys about eleven or twelve years old who would find camping natural and fascinating were selected as subjects. The boys were of homogeneous background and did not know one another before they went to the camp.

None of the boys was aware that he was part of an experiment on group relations ; the investigators appeared as a regular camp staff. To keep the situation as lifelike as possible, experiments were carried out within the framework of regular camp activities and games. Projects were set up which were so interesting and attractive that the boys plunged into them enthusiastically without suspecting that they might be test situations.

Observations were first made to show how the boys became a coherent group. As was to be expected, they quickly formed particular friendships and chose 'buddies'. In a few days the boys were divided into two groups and put into different cabins. Before this happened each boy was asked informally who his best friends were, and then 'best friends' were placed in different groups so far as possible.

A group of strangers brought together in some common activity soon acquires an informal and spontaneous kind of organization. It comes to look upon some members as leaders, divides up duties, adopts unwritten norms of behaviour, and develops an *esprit de corps*. These boys followed this pattern as they shared a series of experiences. In each group the boys pooled their efforts, organized duties and

divided up tasks in work and play. Within a few days one person had proved himself more resourceful and skilful than the rest.

These developments were closely watched, and the boys' relative positions in the group were rated.

Wayward members who failed to do things 'right' or who did not contribute their bit to the common effort found themselves receiving the 'silent treatment', ridicule or even threats. Each group selected symbols and a name.

Conclusions on every phase of the study were based on a variety of observations, rather than on any single method. For example, a game was devised to test the boys' evaluations of one another. It was found that the boys consistently over-estimated the performances by the most highly regarded members of their group and under-estimated the scores of those of low social standing.

When the two groups in the camp had developed group organization and spirit, the experimental studies of intergroup relations was begun.

The working hypothesis was that, when two groups have conflicting aims, their members will become hostile to each other even though the groups are composed of normal well-adjusted individuals. To produce friction between the groups of boys, a tournament of games was arranged. The tournament started in a spirit of good sportsmanship. As it progressed, good feeling soon evaporated. The members of each group refused to have anything more to do with individuals in the opposing group.

Within each group solidarity increased, but co-operativeness and democratic behaviour did not carry over to the group's relations with other groups.

The next problem investigated was how two groups in conflict could be brought into harmony. The observers first undertook to test the theory that pleasant social contacts between members of conflicting groups will reduce friction between them. Far from reducing conflict, these situations only served as opportunities for the rival groups to berate and attack each other.

The observers also believed that, just as competition generates friction, working in a common endeavour should promote harmony. Where harmony between groups is established, the most decisive factor is the existence of 'superordinate' goals which have a compelling appeal for both but which neither could achieve without the other. To test this hypothesis experimentally, a series of urgent and natural situations which challenged the boys were created. One was a breakdown in the water supply. Both groups promptly volunteered to search the 'water line' for the trouble. They worked together harmoniously, and before the end of the afternoon they had located and corrected the difficulty. Other situations showed similar *rapprochements*. These joint efforts did not immediately dispel hostility; but gradually the series of co-operative acts reduced friction and conflict. In the end, the groups were actively seeking opportunities to mingle, to entertain and 'treat' each other. Interviews with the boys confirmed this change. From choosing their 'best friends' almost exclusively in their own group, many of them shifted to listing boys in the other group as 'best friends'.

What these limited experiments have shown is that the possibilities for achieving harmony are greatly enhanced when groups are brought together to work towards common ends. Favourable information about a disliked group is then seen in a new light, and leaders are in a position to take bolder steps towards co-operation. In short, hostility gives way when groups pull together to achieve overriding goals which are real and compelling to all concerned.

PROBABLE EXISTENCE OF RADIOACTIVE MANGANESE-53 IN IRON METEORITES

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WE believe that the half-life of manganese-53 is much longer than previously believed, and that the amount of manganese-53 radioactivity produced in iron meteorites exposed to cosmic ray fluxes in solar space for a million years or more within the past few million years should be easily detectable. Further, we think that the determination of manganese-53 activity in meteorites and elsewhere could have a considerable number of interesting uses because of its long half-life.

Recently, Jeffries[1] has found the spin of manganese-53 to be 7/2 and the magnetic moment $|\mu(^{53}\mathrm{Mn})|$ to be 5·02 nuclear magnetons. This is consistent with the assignment of the ground-state of manganese-53 as a 7/2-state. Since the ground-state spin of chromium-53 has been found to be 3/2, the decay of manganese-53 is almost certainly a 7/2- → 3/2-transition. Such a second forbidden transition should have a logft value[2,3] of 12·2–13·5 and a half-life of 1×10^6 to 2×10^7 yr. if a pure orbital electron capture activity[4] and a decay energy[5,6] of 598 keV. are assumed. Nineteen counts per minute of a long-lived manganese-53 activity have been produced[4] by the reaction $^{53}\mathrm{Cr}(p,n)^{53}\mathrm{Mn}$, and these results have been used to calculate a half-life of 140 years. However, this estimate was based upon some rather uncertain assumptions, of which one at least has now been shown to be wrong. It seems probable, therefore, that the half-life of manganese-53 is much longer than 140 years. In fact, if one uses the cross-section for the production of manganese-53 measured by Jeffries[1] from the strength of the hyperfine structure lines and the activity observed by Wilkinson and Sheline[4], together with the appropriate integrated fluxes of particles used in the two bombardments and factors for the geometry, self-absorption and target differences, calculation gives a half-life of 2×10^6 yr. for this activity. Uncertainties involving the differences in the targets used in the two bombardments and other factors

mean that this measured half-life is uncertain by a factor of ten. Comparing this estimate with that obtained from β-decay theory above, the agreement is better than could have been expected. In any event, it is certainly important for the development of the ideas presented here to determine experimentally a more accurate half-life for manganese-53.

Such an activity should be produced by the effect of cosmic rays on iron, the most prominent reaction being $^{56}Fe(p,\alpha(\text{or its equivalent}))^{53}Mn$. In particular, one would expect to observe the activity in iron meteorites which have been exposed to cosmic ray fluxes within the solar system for a time comparable with the half-life of manganese-53 and which have fallen so recently that the activity has not died away. Singer[7] has suggested that meteorites may be used as integrating cosmic ray meters by virtue of the production in them of tritium by the secondary effects of primary cosmic radiation. He has also suggested the possibility of observing tritium in meteorites. Paneth and his school[8] have been able to demonstrate the existence of tritium in meteorites. More recently, Fireman[9] has determined the existence and amount of tritium in very recently fallen meteorites. However, the long half-life of manganese-53 makes it particularly valuable as a dating tool in studying meteorites. In addition, the facts that 90·9 per cent of iron meteorites[10] are iron and 91·6 per cent of iron is iron-56 ensure an ideal target for the production of manganese-53. It may be remarked that in stone meteorites the production of aluminium-26, which has a half-life of about 10^5 yr., might be used in much the same way, though the presence of large quantities of other aluminium isotopes would render the experimental work much more difficult.

Unfortunately, there are no experimental measurements of the cross-sections for the production of manganese-53 from iron. Therefore, at the suggestion of Prof. T. W. Bonner, we have assumed that the cross-section in the region of 10 MeV. for the bombarding protons is about 1/3 barn, being inversely proportional to the bombarding energy at higher energies. At high proton energies (1 BeV.) the dependence of cross-section on $1/E$ is in reasonable agreement with the total cross-section calculated from the probability of production of one- and two-prong stars in emulsions exposed to the cosmic radiation at high altitudes. At lower energies the cross-section drops very rapidly, so that it may be assumed to be negligible for protons of energy less than about 7 MeV.

Using the assumed cross-section and the data given by Peters[11] on the energy spectrum and intensity of the cosmic radiation for energies greater than 350 MeV., an attempt has been made to estimate the expected intensity of the activity in a newly fallen meteorite. The absorption length of the star-producing radiation in iron is assumed to be 5/2 the interaction length[12] (13·7 cm.), so that some account is taken of the effects of high-energy knock-on protons and the fact that the π-mesons produced will interact rather than decay in a dense material. Details of the numbers and energies of secondary protons produced in disintegrations by the primary cosmic ray particles have been taken from nuclear emulsion studies[13,14], being reduced by a small factor to take into account the fact that the iron nucleus is smaller than those of silver and bromine, in which most of the interactions take place in the emulsion.

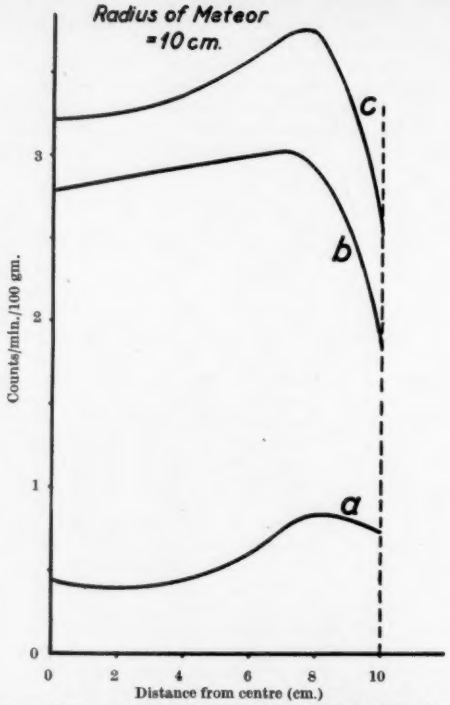

Fig. 1. The expected manganese-53 activity as a function of the distance from the centre of a spherical meteorite of radius 10 cm. Curve *a*: activity due to low-energy primary cosmic radiation; curve *b*: activity due to high-energy primary cosmic radiation; curve *c*: total activity

On the assumption that secular equilibrium has been reached, the rate of production will be equal to the rate of decay found in a newly fallen specimen.

Also of interest to the cosmic-ray physicist is the intensity of the very low-energy radiation outside the influence of the Earth's magnetic field. On the assumption that Peters's spectrum may be extrapolated down to 100 MeV., a separate calculation has been made of the intensity of the activity due to this part of the beam. These expected activities have been calculated as a function of the distance from the centre of a meteorite of 10 cm. radius. The results are shown in Fig. 1. The shape of these curves is of interest. The most intense activity would seem to be expected from a shell about 3 cm. under the original surface (before ablation by the Earth's atmosphere). It may be remarked that an intense beam of very low-energy protons, such as those that have been supposed to be responsible for the aurora borealis, would be expected to produce a sharp rise in the activity within 1 cm. of the surface of the meteorite. With respect to the shape of the curves, it should also be remarked that a more detailed calculation of the meson–nucleon cascade might be expected to emphasize somewhat the maximum in the activity produced by the high-energy component of the radiation at a depth of 3 cm. Further, we stress that the absolute numbers are dependent on the assumptions discussed above.

However, in spite of considerable possible errors in the estimates of the production cross-section for manganese-53, it seems probable that an easily observed activity of manganese-53 should result if

manganese is extracted from 100 gm. of recent meteoric iron. Fortunately, there are only about 3 parts of manganese in every 10,000 parts of iron meteorite. Consequently, the specific activity of manganese-53 will not be so low that self-absorption is a serious problem, particularly if a counter is chosen which employs a large sample area.

At the present time, plans are being made in this laboratory to look for manganese-53 activity in meteorites. This search will at the very least give additional information on the cosmic-ray intensity in solar space. If activity is found, then the determination of the activity in concentric shells as a function of depth should yield information on the intensity of the low-energy cosmic radiation within the solar system. If problems such as the uneven burn-off of the meteorite in our atmosphere can be overcome, it should be possible to date the fall of meteorites by their manganese-53 content. Such dating could presumably go back several million years. One might also hope to learn something about the constancy of cosmic-ray intensity over periods of approximately a million years by studying the relative amounts of tritium and manganese-53 in recently fallen meteorites. Finally, although the amount of manganese-53 produced by cosmic rays at the Earth's surface would demand especially large samples of iron, it is possible that this activity may be accumulated in the polar regions of the Earth's surface for other reasons[15]. If there are appreciable amounts of manganese-53 on the Earth's surface, then the activity might be used as an important geological dating tool. More specifically, one might hope to determine the time of burial of terrains back to a few million years.

We wish to express our appreciation to Prof. Niels Bohr for the ideal working conditions which exist at this Institute. One of us (R. K. S.) wishes also to thank the Institute, the Fulbright Foundation and the Guggenheim Memorial Foundation for the visiting professorship and grants which made this work possible, while the other (J. E. H.) expresses similar thanks to the Rask-Ørsted and Ford Foundations.

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A ZINC-DEPENDENT HEXOKINASE FROM *NEUROSPORA CRASSA*

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ZINC is known to be important for the utilization of carbohydrates by fungi because less sugar is oxidized when there is a deficiency of the metal[1]. Apart from aldolase activity which may be reduced in zinc-deficient plants[2] there is little information on the effect of zinc-deficiency on enzymes concerned in glycolysis.

This communication reports that zinc is specifically required for maximal hexokinase activity in *Neurospora*.

Neurospora crassa wild type 146 (microconidial type) was grown in a Fries culture solution containing glucose instead of sucrose[3]. The metals, iron, copper, zinc, manganese and molybdenum, were removed from the basal culture solutions by the methods described previously[4]; the trace metals used for supplementing the media were checked for purity by means of a spectrograph. The culture solutions were dispensed in 100 ml. amounts in 500 ml. Erlenmeyer flasks, and after sterilizing at 10 lb. sq. in. for 10 min. were cooled and inoculated with a spore suspension of the fungus contained in sterile glass-distilled water. After 4 days growth in the dark at 28° C. the mycelial mats from the normal and the various metal-deficient cultures, collected separately, were well washed with glass-distilled water and frozen at −15° C. They were homogenized in a pestle and mortar with four times their weight of cold glass-distilled water containing 5×10^{-3} *M* sodium ethylene diamine tetra acetic acid and then in a Ten Broeck glass macerater at 0° C. The homogenate was centrifuged at 2,000 *g* for 5 min. More than 90 per cent of the hexokinase activity of the homogenates was in the supernatant. The enzyme was purified by fractionation with ammonium sulphate. Hexokinase was determined by the method of Crane and Sols[5], the enzyme was incubated for a defined period, usually 15 min., at 30° C. with 6 μM sugar, 15 μM adenosine triphosphate (98 per cent pure), 7·5 μM magnesium sulphate and 20 μM each of sodium fluoride and potassium hydrogen phosphate and *tris*-(hydroxymethyl)-amino methane at *p*H 8·0, final volume 0·3 ml. The phosphorylation was followed by determining residual sugar using Somogyi's method[6]. Fructose and fructose-6-phosphate were determined according to Roe's procedure[7]. The specific activity is defined as μmoles glucose phosphorylated in 15 min. per mgm. protein. Protein contents of the fractions were determined by Lowry's method[8]. Glucose-6-phosphate was identified as the product of reaction by paper chromatography[9] and enzymically by the triphosphopyridine nucleotide, glucose-6-phosphate dehydrogenase assay[10].

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Table 1. Effect of Metal Deficiencies on Hexokinase from *N. crassa* Specific Activity (μmoles Glucose esterified 15 min./mgm. Protein)

Treatment of culture solutions	Control	−magnesium*	Control	−iron	Control	−copper	Control	−zinc	Control	−manganese	Control	−molybdenum
Exp. 1	2·33	2·49	3·25	3·3	3·17	2·80	3·09	1·47	2·60	2·20	3·17	4·13
Exp. 2			1·84	1·81	2·82	2·71	1·84	0·95	2·48	2·17	2·82	4·06
Exp. 3					2·97	2·92	2·40	1·19			2·97	3·40

* −Magnesium, one-hundredth of the magnesium content of full culture. Enzyme preparation, 0–100 per cent ammonium sulphate fraction of supernatant (after centrifuging homogenate at 2,000 *g* for 5 min.). 5×10^{-3} *M* sodium ethylene diamine tetra acetic acid in water and dialysed for 12 hr. against 5×10^{-4} *M* sodium ethylene diamine tetra acetic acid in 2×10^{-2} *M tris*(hydroxymethyl)-aminomethane, *p*H 7.

The effects of individual deficiencies of magnesium, iron, copper, zinc, manganese and molybdenum on hexokinase are shown in Table 1.

Deficiencies of magnesium, iron, copper or manganese did not markedly affect the enzyme activity. When molybdenum was deficient, hexokinase increased whereas a zinc deficiency depressed it. The effect of adding graded amounts of zinc to zinc-deficient media was to increase the hexokinase activity of the felts. The effect appears to be specific for zinc.

After 4 days growth, zinc-deficient felts were given 200 μgm. zinc per flask aseptically and triplicate cultures were harvested at intervals within a further 24-hr. period. The results, illustrated in Fig. 1, show that the enzyme in the zinc-deficient mats is reconstituted to about 90 per cent of that in the normal felts within 12 hr. of adding the micronutrient.

The enzyme prepared from the zinc-deficient felts was stimulated *in vitro* to 30 per cent of the normal enzyme by the addition of zinc sulphate, over the range 0·59–1·19 μgm. zinc/μmole glucose phosphorylated. Zinc ethylene diamine tetra acetic acid could not be substituted for ionic zinc in this process.

An increase in specific activity of hexokinase in the fractions was not paralleled by a similar increase in zinc content per mgm. protein. Thus zinc may affect the protein moiety only or the metal may be a loosely bound constituent of the enzyme which is readily removed during fractionation.

The inhibition of the enzyme by *p*-chloromercuribenzoate and its reversal by glutathione suggest the presence of —SH groups in the enzyme. The mμmoles —SH/μmole glucose phosphorylated were 0·16 and 0·53 for the enzyme prepared from normal felts and zinc-deficient felts respectively.

The effect of zinc in protecting —SH groups in the enzyme from the inhibitory action of *p*-chloromercuribenzoate is shown in Fig. 2.

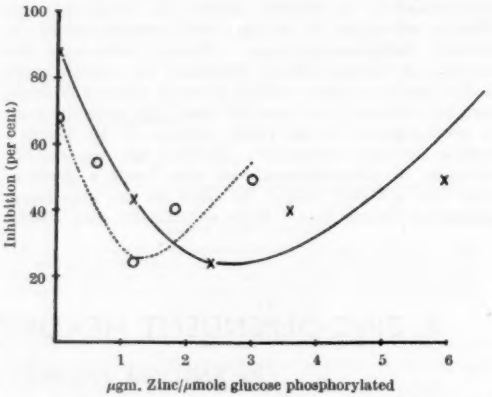

Fig. 2. The Effect of Zinc Sulphate, added *in vitro*, in protecting Hexokinase from Inhibition by 10^{-3} *M p*-chloromercuribenzoate

○——○, enzyme from normal felts; ×——×, enzyme from zinc-deficient felts

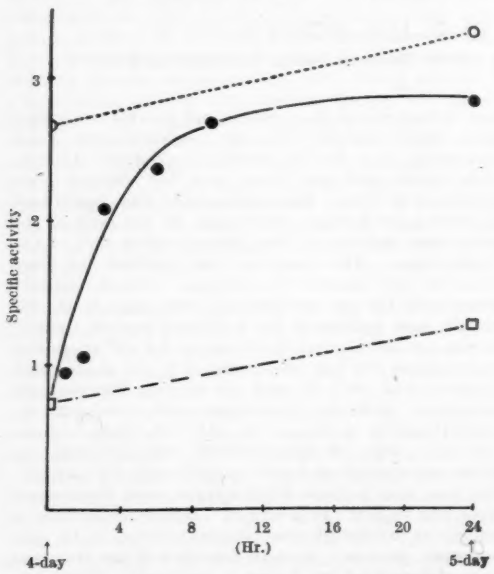

Fig. 1. Reconstitution of Hexokinase in Zinc-deficient Felts

○---○, complete nutrient; □-·-·-□, zinc deficient; ●——●, 200 μgm. zinc added aseptically to zinc-deficient felts after 4 days growth and enzyme production followed at intervals within a further 24-hr. period

Maximum protection from inhibition by *p*-chloromercuribenzoate is afforded by incubating the normal enzyme with 1·2 μgm. zinc and the enzyme from zinc-deficient felts with 2·5 μgm. zinc/μmole glucose phosphorylated. The addition of other metals at similar concentrations, for example, copper or iron, was without effect on the inhibition of the enzyme by *p*-chloromercuribenzoate. Zinc cannot reverse the inhibition of the enzyme when the mercurial is added first to the enzyme.

A full account of this and related work will appear in the *Biochemical Journal*.

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EFFECT OF WAVE-LENGTH ON THE DISTRIBUTION OF CARBON-14 IN THE EARLY PRODUCTS OF PHOTOSYNTHESIS

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RECENTLY, Voskresenskaya[1] (quoted by Nichiporovich[2]) reported that in plants carrying on photosynthesis in the presence of $^{14}CO_2$, the distribution of radioactive carbon between proteins and carbohydrates depended upon the wave-length of light to which the plants were exposed. Both authors agreed that the red end of the spectrum favoured the appearance of radioactivity in carbohydrates, while the blue favoured incorporation into proteins.

The techniques specified by Voskresenskaya[1] for separating protein and carbohydrate fractions (lead acetate precipitation of proteins) would be expected to result in contamination of the 'protein' fraction with phosphate esters of carbohydrate precursors. The experimental evidence, therefore, provides only an uncertain foundation for the conclusion drawn.

Since the question whether colour of light may modify the sequence of reactions in photosynthesis is important, we thought it desirable to make comparisons similar to those made by Voskresenskaya and Nichiporovich, but based upon more reliable methods of separation. Instead of comparing carbohydrates and proteins, we studied the precursors of these substances, the phosphate esters and amino-acids.

We report here measurements of the distribution of carbon-14 in these fractions following photosynthesis in the presence of carbon dioxide labelled with carbon-14.

The experiments were made with *Chlorella* cells (*C. pyrenoidosa* Chick, Emerson's strain), suspended in acid culture medium. Blue and red light were isolated from the light of 400-watt mercury-cadmium lamps by means of filters. The red beam included the cadmium line at 644 mμ and was free from all shorter wave-lengths, but was contaminated with a small amount of radiation of longer wave-lengths. The filter combination for blue light transmitted primarily the mercury line at 436 mμ with small amounts of energy from lines of longer wave-length out to the 546 mμ line, as well as from the 406 mμ mercury line. For both the red and the blue light, the incident intensity at the reaction vessel was approximately 8 micro-einsteins/cm.²/min.

The reaction vessel was illuminated from both sides, by means of two lamps and duplicate sets of lenses and filters. The volume of the reaction vessel was about 20 ml., and the light path about 10 mm. A cell density of 10 μl. per ml. was sufficient to give total absorption of the incident light at both 436 and 644 mμ.

The cells were pre-illuminated for 5 min. in the absence of added carbon dioxide (to minimize dilution of the labelled carbon dioxide to be added). This was followed by addition of $^{14}CO_2$ as bicarbonate and exposure was continued for 30 sec. A sample of cells was then withdrawn under sharply reduced pressure into a vessel that contained a measured quantity of absolute ethanol to give a final concentration of 70 per cent after mixing. Extraction in the 70 per cent alcohol was continued for thirty minutes at room temperature, and the extract was fractionated by paper chromatography to separate the amino-acids and phosphate esters (together with free sugars, organic acids, etc.). The phosphate esters were chemically separated into barium acetate-insoluble (BI) and barium acetate-soluble – alcohol-insoluble (BSAI) residues. The incorporation of carbon-14 in the various fractions was determined by conventional counting methods.

In these experiments, no correction was made for incorporation of carbon-14 through dark processes, because measurements showed that in darkness the rate of incorporation was less than 1 per cent of that in the light.

Table 1. A COMPARISON OF CARBON-14 INCORPORATION IN AMINO-ACIDS AND PHOSPHATE ESTERS; 30-SEC. PHOTOSYNTHESIS AT 436 mμ AND 644 mμ

λ	Fraction	Total (ct./min.)	SAA* (ct./min./mgm.)	SAA 436 mμ* / SAA 644 mμ
436 mμ	Amino-acids	13,760	220,500	1·7
	BI } Phosphate esters	296,500		
	BSAI }			
	Total	310,260		
644 mμ	Amino-acids	10,150	132,400	
	BI } Phosphate esters	272,500		
	BSAI }			
	Total	282,650		

* SAA = specific activity of amino-acids.

Table 1 shows a comparison of carbon-14 incorporation in amino-acids and phosphate esters during thirty seconds of photosynthesis at 436 and 644 mμ.

For the sum of radioactivity incorporated in amino-acid and phosphate ester fractions, the table shows 282,650 counts per minute after photosynthesis in red light, and 310,260 after photosynthesis in blue. The difference is minor, and we attribute no significance to it. In most cases, the sum of activity in these two fractions was the same for red and blue light, within the experimental error. The fraction going into the combined amino-acids was generally not very different for red and blue light (in the experiment tabulated, it was 3·6 per cent for photosynthesis in red, and 4·4 per cent for blue). However, the

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Table 2. Incorporation in Individual Amino-acids during 30-sec. Photosynthesis at 436 mμ and 644 mμ

λ	Amino-acid	SAA* (ct./min./mgm.)	SAA 436 mμ* / SAA 644 mμ
436 mμ	Alanine	187,000	
	Glycine	145,300	
	Serine	110,800	
644 mμ	Alanine	62,300	3·0
	Glycine	58,000	2·5
	Serine	58,300	1·9

* SAA = specific activity of amino-acids.

difference was consistently in this direction, and must therefore be regarded as significant, even though small. This apparently small difference between the effects of blue and red light becomes more striking if we compare specific activities (activity per mgm. material). The specific activity of the amino-acids is almost twice as great after photosynthesis in blue as it is after photosynthesis in red. This greater specific activity in the amino-acids, following photosynthesis in blue light, together with the nearly equal counts per minute in the amino-acid fraction for both red and blue light, implies, of course, that in the experiment tabulated the amount of amino-acids in the isolated fraction must have been smaller after photosynthesis in blue than after photosynthesis in red light.

Table 2 shows some of the specific activities for individual amino-acids. Alanine, glycine and serine show specific activities greater at 436 mμ than at 644 mμ, by factors of 3·0, 2·5 and 1·9, respectively.

Alanine and glycine eluted from the chromatograms and co-crystallized with carrier amino-acids were degraded to show the distribution of labelling. The results of such an experiment are shown in Table 3.

The distribution of the tracer in alanine at both wave-lengths was similar to that reported by Calvin *et al.*[3] for this amino-acid after photosynthesis in white light. Here we find the heavy label in the carboxyl carbon, and much less activity in the alpha and beta carbons, but with approximately equal labelling in these two positions. We do not consider the slight differences in the distribution of the label at 436 mμ and 644 mμ to be significant.

The pattern of labelling in the alanine is essentially the same as that reported for phosphoglyceric acid[2,5] and is consistent with the interpretation that this amino-acid arose from the phosphate ester by way of pyruvic acid and a transamination.

The distribution of labelling in glycine after photosynthesis at 644 mμ was similar to that reported for this amino-acid by Vernon and Aronoff[4] following 15 sec. of photosynthesis by soybean leaves in white light. There was a slight preponderance of activity in the alpha carbon atom. On the other hand, in our experiments with blue light we found quite a different distribution of labelling in the glycine. The slight preponderance of labelling found in the alpha carbon after photosynthesis at 644 mμ was replaced by a greater preponderance in the alpha carbon following photosynthesis at 436 mμ. This heavy labelling in the alpha carbon is difficult to interpret, unless one supposes that during photosynthesis in blue light the carbon dioxide was converted to glycine by way of formate and glyoxylate.

Table 3. The Effect of Blue and Red Light on the Distribution of Carbon-14 in Alanine and Glycine; 30-sec. Photosynthesis

λ	Amino-acid	SAA* Total activity of amino-acid (dis./sec./m.mole)	Activity in each carbon (dis./sec./m.mole)	Per cent of the total activity in each carbon	SAA 436 mμ* / SAA 644 mμ
436 mμ	Alanine	495			
	C^1 OOH		326	65·9	
	H C^2 NH_2		98	19·8	
	C^3 H_3		65	13·1	
	Total		489		
	Glycine	192			
	C^1 OOH		42	21·9	
	H_2 C^2 NH_2		150	78·1	
	Total		192		
644 mμ	Alanine	184			
	C^1 OOH		129	70·0	
	H C^2 NH_2		27	14·7	2·7
	C^3 H_3		26	14·1	
	Total		182		
	Glycine	67			
	C^1 OOH		28	41·8	
	H_2 C^2 NH_2		38	56·7	2·9
	Total		66		

* SAA = specific activity of amino-acids.

To summarize, our results do not indicate preferential synthesis of carbohydrates during photosynthesis in red light, or preferential protein synthesis in blue light. However, we did find significantly greater specific activities of the amino-acids produced at 436 mμ, with glycine displaying an interesting pattern of distribution of the label incorporated within the molecule.

A more extensive report of this work will be presented elsewhere.

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LETTERS TO THE EDITORS

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Relative Abundances of Different Charge Groups of Heavy Primary Cosmic-Ray Nuclei

SINCE the discovery in 1948 [1] that primary cosmic rays entering the Earth's atmosphere contain nuclei of elements ranging in size up to iron, many measurements have been made to establish the charge distribution of the primary radiation. Knowledge of this distribution is of crucial importance for astrophysical investigations into the origin of cosmic rays. There is agreement between different laboratories regarding the flux of nuclei of medium charge, M nuclei, but disagreement on the flux of both light (L) ($3 \leqslant Z \leqslant 5$) and heavy ($H$) ($Z > 10$) charge groups. Figures given for the relative primary abundances of L and M nuclei exhibit a particularly wide spread, for L/M ranges from $< 0{\cdot}1$ to $> 1{\cdot}0$. The spread in published values of the heavy-to-medium ratio is less, 0·2 to 0·5, but enough to make further work necessary.

The main reasons for the conflict between the results are the experimental difficulties of separating the charge groups and, especially for H nuclei, the smallness of the numbers found in any one experiment. Also, in all experiments involving high-altitude balloon flights, there is some atmosphere above the detector (for example, 11 gm./cm.^{2} at 100,000 ft.) and, in addition, packing and other materials are traversed by the incident radiation. Since the interaction mean free path is only about 18 and 26 gm./cm.^{2} for the heavy and medium groups respectively[2], it is necessary to have balloon altitudes well above 100,000 ft. if the corrections for the effects of interactions are to be kept small. This is particularly important because L-group nuclei are frequently produced in the interactions of heavier nuclei.

If the ratio L/M at flight altitudes around 100,000 ft. were of order 0·1, all observed L nuclei would probably be secondary fragmentation products, but a value of order 1·0 would prove that light nuclei exist in the primary radiation.

We have recently completed an experiment to determine whether L nuclei are abundant in the primary radiation or not. Detailed accounts will appear shortly[3]. The results were obtained from a large-area stack of nuclear-emulsion sheets without glass support, flown for around 6 hr. at above 110,000 ft. (8·6 gm./cm.^{2} air + 2 gm./cm.^{2} packing) in Texas (41° N. geomagnetic), in February 1956.

In Table 1 we give our absolute fluxes and relative abundances both for flight altitude and extrapolated to the top of the atmosphere. The extrapolation was carried out using the usual diffusion equations[3], and two different values[3,4] were used for the probability p of a light nucleus being produced in an interaction of a heavier primary one in the atmosphere above the stack. Table 1 contains, for comparison, the cosmic abundances obtained from astrophysical data by Suess and Urey[5]. The results show (*a*) that lithium, beryllium and boron are definitely present in the primary radiation, and (*b*) that the relative abundances of the different charge groups found in cosmic rays are quite different from those given for matter in the universe[5]. The L group is more than 10^3 times as abundant (relative to the M group) in cosmic rays as in the universe, and the heaviest nuclei (the H group) appear to be relatively six times more common in cosmic rays.

Table 1

	$Z=2$	$3 \leqslant Z \leqslant 5$	$6 \leqslant Z \leqslant 10$	$Z>10$
Flight altitude : Numbers found		46^{+10}_{-7}	46 ± 7	20 ± 4
Relative to M group		1·00	1·00	0·43
Top of atmosphere : Flux* with $p=0{\cdot}45$	100 ± 20	3·5	5·5	2·6
$p=0{\cdot}23$		4·2	5·5	2·6
Relative to M group $p=0{\cdot}45$	18	0·64	1·00	0·47
$p=0{\cdot}23$		0·76	1·00	0·47
Cosmic abundances (relative to M group)	100	5×10^{-4}	1·00	0·08

* Fluxes are given in particles m.$^{-2}$ sec.$^{-1}$ sterad.$^{-1}$

The observed cosmic-ray charge distribution depends not only on the relative abundances in the source regions but also on the acceleration mechanism and the fragmentations in collisions with matter encountered during acceleration or in interstellar space. If L nuclei are absent in the source regions, and if they are not produced during acceleration there, the light-element flux must be due to fragmentations with interstellar material so that one can derive from it an upper limit to the time cosmic rays have travelled before reaching the Earth's atmosphere. Assuming that most interstellar matter is hydrogen with a density of 1 atom/cm.^{3}, our data give a travel time of the order of a few million years. If light nuclei occur in the source or are produced during acceleration there this time is reduced.

The large proportion of nuclei with $Z > 10$ is of great importance, for it implies either that very heavy nuclei are more abundant in cosmic-ray source regions than in the rest of the universe or that the acceleration mechanism strongly favours heavy nuclei, or both. Recent work on supernovæ[6] and on possible mechanisms of accelerating particles to cosmic-ray energies in them[7] suggests that supernovæ might be a source of cosmic rays giving a charge distribution with a high proportion of heavy elements. This hypothesis could be tested if the effects of fragmentations were better understood, and if the charge spectrum of heavy nuclei were known in greater detail.

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Abundances of Meteoric Lead Isotopes

In a recent publication Patterson[1] shows that the measured isotopic abundances of leads from five different meteorites and recent terrestrial ocean sediments are simply related. From this fact, following a series of convincing arguments, he deduces that all these leads have developed from a single primeval lead by the addition of radiogenic lead-206, lead-207 and lead-208, and that the additions of radiogenic lead commenced at a common time $(4{\cdot}55 \pm 0{\cdot}07) \times 10^9$ years ago. Without disputing any of these arguments, I wish to point out some interesting features of the meteoritic lead-isotope ratios which appear when they are compared with the observed ratios of these isotopes in terrestrial lead minerals.

Patterson's calculation is based on an application of Holmes's equation[2], namely,

$$\frac{y - y_0}{x - x_0} = \frac{1}{\alpha} \cdot \frac{\exp \lambda' t_0 - \exp \lambda' t}{\exp \lambda t_0 - \exp \lambda t}$$

In this equation x and y, and x_0 and y_0 are the ratios $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ at the time t of isolation of lead as a mineral, and at some initial time t_0 before which lead abundances were everywhere the same. λ, λ' and α are constants equal to $0{\cdot}153(7) \times 10^{-9}$ (yr.)$^{-1}$, $0{\cdot}972(2) \times 10^{-9}$ (yr.)$^{-1}$ and 137·8, respectively. This equation, which applies only to closed systems containing uranium and lead, has been used recently by Holmes and Cahen[3] for calculating ages for many African galenas with results in apparent agreement with independently estimated geological ages, particularly in the case of palæozoic and younger minerals, where agreement was often within a few tens of millions of years.

Now if the meteorites are very old and unaltered, they should provide closed systems for uranium and lead, and this assumption in the equation should be fulfilled much more rigorously than in the case of terrestrial rocks, where the gross transport of materials has taken place. Therefore, it is interesting to try to 'date' the meteorites by the same method o calculation as has been used for galenas.

To do this I have taken as the lead ratios x_0 and y_0 in primeval lead the average of the ratios measured by Patterson for iron meteorites. These contain negligible uranium and thorium and therefore may represent the lead with which the members of the solar system were originally endowed. I have used his ocean sediment lead ratios for defining the present-day isochron and thus evaluate t_0. This gave $t_0 = 4{\cdot}50_5 \times 10^9$ yr., essentially the same as Patterson's result, differing slightly because I have used only three of the five values used by him. The 'ages' obtained for the three stones are given in Table 1.

Table 1. Lead Isotope Ratios from Patterson (ref. 1) and Calculated 'Ages' of Three Stone Meteorites

Description	206/204	207/204	'Age' value*
Henbury, Australia (iron meteorite)	9·55	10·38	Primeval lead
Canyon Diablo, Arizona (iron meteorite)	9·46	10·34	
Ocean sediments	19·0	15·8	Zero by def'n.
Nuevo Laredo, Mexico (stone meteorite)	50·28	34·86	330 m.y.
Forest City, Iowa (stone meteorite)	19·27	15·96	5 m.y.
Modoc, Kansas (stone meteorite)	19·48	15·76	−420 m.y.

* Calculated time at which uranium lead ceased to be added to the lead in the meteorite.

If the three stones had remained isolated, closed systems until recent times, all ages should be zero within experimental error. This is the case for the Forest City meteorite, which (perhaps by coincidence) is the only one of the three which has been dated at 4,000–4,500 million years by both the potassium–argon and rubidium–strontium methods. We therefore know that it has remained unaltered for the last 85–90 per cent of its lifetime, at least.

If these were terrestrial lead minerals, we would say that Nuevo Laredo lead had been isolated from the greater part of its uranium about 330 million years ago, and that Modoc lead was anomalous[4] (cf. Houtermans's[5] J-type lead), having been exposed to much larger proportions of uranium during the recent past than during the rest of its history. Evidence for the latter conclusion would then be considered to be well outside experimental error. For example, Houtermans[6] has shown by direct measurements of lead-210 that cotunnite lead from Vesuvius, which gives a negative age of only about 200 million years, has been recently in an environment ten times richer in uranium than the average source rock for all leads.

Thus although the meteoritic isotope ratios fit a single isochron so closely that they provide an excellent estimate of the age of the Earth-meteorite system, they deviate from it by amounts that would be considered clearly significant in the case of terrestrial lead minerals. Assuming that the reproducibility of the meteorite lead analyses is as good as that generally obtained for ore leads, one must conclude that either the three stones were formed at significantly different times (corresponding to t_0 values differing by a few tens of millions of years), or that Nuevo Laredo and Modoc have experienced chemical alteration in the past few hundred million years. The second possibility would demand that potassium–argon measurements on these two meteorites give young ages since radiogenic argon would escape at the time of alteration, and that Nuevo Laredo contains less uranium than would be calculated from its radiogenic lead content. Suess and Urey[6] have recently directed attention to the fact that present experimental evidence does suggest a deficiency of uranium in Nuevo Laredo.

Therefore the isotopic data of Patterson could be interpreted as indicating recent chemical alteration of some stone meteorites.

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A Fast Method for reaching Equilibrium in the Ultracentrifuge

The inherent power of the equilibrium method[1] for study of molecular weight, polydispersion, and activity coefficients in the ultracentrifuge has been limited by the length of time required to reach equilibrium. We have found that this time can be appreciably reduced by using the synthetic boundary cell[2] and by selecting the starting conditions—speed

of the ultracentrifuge, the relative heights and the relative concentrations of the two layers—in accordance with a mathematical analysis of the approach to equilibrium.

The approximate[3], as well as the exact[4], solutions by Archibald of the ultracentrifuge differential equation are not useful in our problem because of the extensive numerical computation needed for each set of experimental conditions. We have obtained a manageable solution by a perturbation treatment of the centrifuge equation, retaining terms of the first order in the parameter $\lambda = (r_b - r_t)/(r_b + r_t) \approx 0{\cdot}05$, where the r's are distances of the cylindrical surfaces of the equilibrating solution from the axis of rotation. For the analysis required here, however, the zero order approximation is adequate. This approximation corresponds to the exact solution of Mason and Weaver[5] for sedimentation in a uniform gravitational field.

The concentration of an equilibrating component having sedimentation and diffusion coefficients S and D is

$$C(\rho,\tau) = C^*(\rho) + \exp \alpha\rho \; . \exp(-\alpha\tau/2) \sum_{n=1}^{\infty} A_n X_n(\rho) \exp(-n^2\pi^2\tau/2\alpha) \quad (1)$$

where

$$\rho = (r - r_t)/H, \; H = r_b - r_t; \quad \alpha = HV/2D, \; V = S\omega^2 (r_b + r_t)/2;$$

$$\tau = t/t_0, \; t_0 = H/V; \; X_n(\rho) = \cos n\pi\rho + (\alpha/n\pi) \sin n\pi\rho,$$

and where the asterisk denotes equilibrium. Since $C^* = A_0 \exp 2\alpha\rho$, α determines the final distribution in the zero order approximation. It also determines the exact distribution, as is shown by its equivalence with the familiar expression

$$\ln \frac{C^*_b}{C^*_t} = \frac{M(1 - \bar{v}\rho)\,\omega^2(r_b^2 - r_t^2)}{2RT} = \frac{S}{D} \frac{\omega^2(r_b^2 - r_t^2)}{\times \; 2} = \frac{VH}{D} = 2\alpha \quad (2)$$

For a given value of α the A_n's are constants which are determined by the initial distribution of concentration.

Because the time exponential in (1) involves n^2, the deviation from equilibrium after a short time is given by the leading term of the sum, $n = 1$; equilibration will be accelerated if it is possible to choose initial conditions such that A_1 vanishes.

For the initial condition

$$C(\rho,0) = \begin{cases} C_1, & 0 < \rho < \beta \\ C_2, & \beta < \rho < 1 \end{cases}$$

where β is the position of the synthetic boundary, A_1 can be made to vanish if C_2/C_1 and β are chosen so as to satisfy

$$C_2/C_1 = (\gamma_1 - \exp \beta\alpha)/(\gamma_1 + \exp\{-(1-\beta)\alpha\} \quad (3)$$

with

$$\gamma_1 = \cos \pi\beta - [(\pi^2 - \alpha^2)/2\pi\alpha] \sin \pi\beta$$

In Fig. 1, C_2/C_1 is plotted against β according to equation (3) for the case of $\alpha = 0{\cdot}6$, that is, $C^*_b/C^*_t = 3{\cdot}3$. The curve shows that there exists a wide range of choices for the location of the synthetic boundary, all of which are consistent with the vanishing of A_1. It is interesting to note that pure solvent may be used as the top layer ($C_2/C_1 = \infty$) if the boundary is placed at $\beta = 0{\cdot}19$. It is also to be noted that in the vicinity of $\beta = 0{\cdot}55$ the curve has a broad

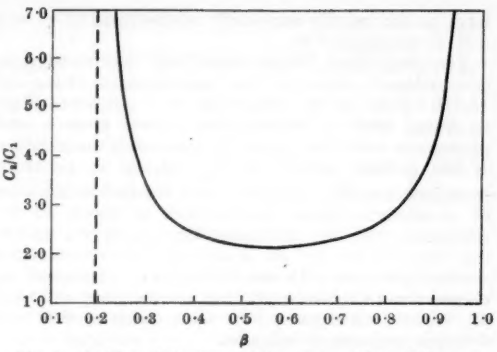

Fig. 1. Position of the step and the corresponding relative concentrations in the layers that cause A_1 to vanish. Calculated from equation (3) for $\alpha = 0{\cdot}6$, that is, $C^*_b/C^*_t = 3{\cdot}3$

minimum and the system is insensitive to filling errors.

We turn now to a consideration of the saving in time brought about by starting with a step distribution chosen in accordance with equation (3). We define equilibrium as the state in which the concentration deviates nowhere by more than 1 per cent from the concentration at true equilibrium, and let τ^* be the value of τ calculated from equation (1) for this equilibrium state. In applying the fast method to an actual system the value of α will be incorrectly estimated (also the system may be polydisperse and therefore possess a range of α values) so that the step distribution will be incorrectly chosen and A_1 will not quite vanish. The effect of an error of this kind on τ^* is shown by curve *a*, Fig. 2. Compared with the conventional method, there is an eight-fold reduction in time when the value of α for the system agrees exactly with the value assumed and about a two-fold reduction when the error in α is approximately 15 per cent, curve *c*. The saving of time results from setting up step distributions to approximate the final distribution and from advantageous combinations of sedimentation and diffusion to transport material.

For the above comparison, we have also evaluated τ^* for an initially uniform distribution from equation (1); the results are plotted as a function of α in curve *b*. The equilibrium distributions of interest in the ultracentrifuge are $C^*_b/C^*_t = 2$–4, and correspondingly, $\alpha = 0{\cdot}4$–$0{\cdot}7$. This leads according to curve *b* to $\tau^* \approx 0{\cdot}5$, and to values of t^* one-fourth as

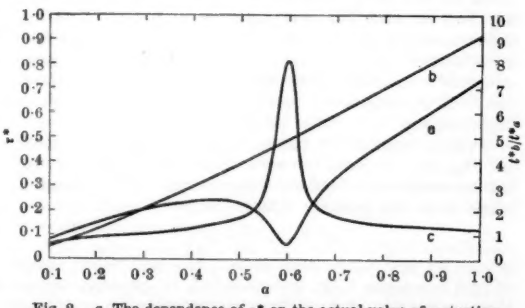

Fig. 2. *a*, The dependence of τ^* on the actual value of α starting with the step distribution, $\beta = 0{\cdot}5$, $C_2/C_1 = 2{\cdot}17$, chosen on the basis of $\alpha = 0{\cdot}6$. *b*, The dependence of τ^* on α starting with a uniform solution. *c*, The ratio of times required to reach equilibrium in systems *b* and *a*

large as are usually expected[6] on the basis of $\tau^* = 2$ (ref. 1, equation 108).

The theoretical results have been confirmed with ribonuclease (Armour) in experimental runs at 13,410 r.p.m. in the Spinco Model *E* ultracentrifuge equipped with a temperature-control system and phaseplate schlieren optics. A stationary distribution of the protein, which did not appear to be truly homogeneous ($\overline{M}_z = 14{,}800$), was reached in the case of a uniform initial distribution in about 40 hr. compared with the calculated time of 36 hr., and in less than 20 hr. for an initial step distribution for which C_2/C_1 was 2·12 and β was 0·53. The speed, ω, chosen from (2) was such that the assumed value of M, 13,600, corresponded to an α value of 0·6 in a 0·61-cm. column of solution.

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Temperature Coefficient of Resistivity of Polythene and Oil-impregnated Paper

The distribution of d.c. electric stress in insulation is controlled by the resistivities of the dielectrics involved. In turn, the resistivity at any point is a function of the temperature at that point. Thus in order to compute the electric stress under d.c. conditions, a knowledge of the variation of the resistivity of the dielectric with temperature after long periods of electrification is necessary. Some data on the properties of polythene have been given by Fowler and Farmer[1] and by Ramsey[2]; but the agreement is poor, and in general the published information is scant. Accordingly, it has been necessary to make some measurements on polythene and oil-impregnated paper in connexion with a high-voltage d.c. cable project.

Typical results for three cable materials are given in Fig. 1. It will be seen that the resistivity (ρ) varies with the absolute temperature (T) in accordance with the general relationship:

$$\rho = \rho_0 \exp(b/T)$$

where ρ_0 and b are constants. Electrification times of not less than 1 hr. were needed, in general, before the resistivity of polythene approached a constant value.

The values of b for the three curves shown in Fig. 1 are 12,500, 13,100 and 9,700 for polythene,

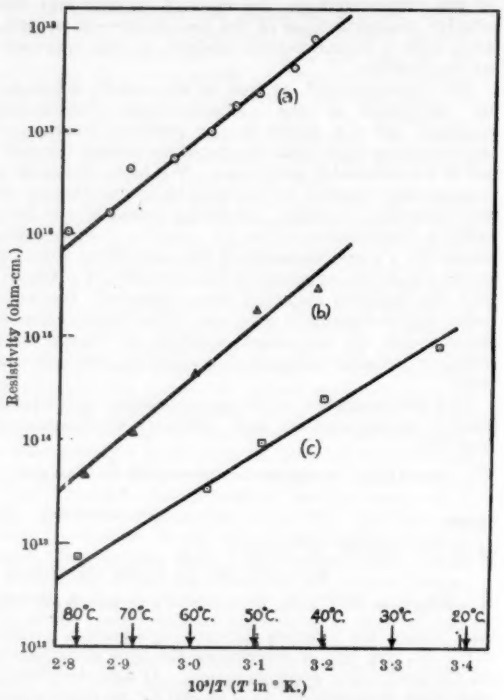

Fig. 1. Variation of resistivity with temperature: *a*, polythene cable; *b*, mass-impregnated non-draining cable; *c*, mass-impregnated oil–rosin cable from service

non-draining and oil–rosin cable respectively. The value for polythene lies between the two values obtained by the workers mentioned above.

This work is being continued; but in the meantime it is hoped that the values of temperature coefficient obtained will assist others engaged on similar problems.

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Structure of Bone in Relation to Growth

In a recent communication[1], Jackson and Randall have shown, using electron microscopy and electron diffraction, that at a very early stage in the development of bone, apatite crystals are deposited in what appears to be a definite relationship to the collagen fibres. They did not, however, find any evidence of preferred orientation of the crystals. The samples examined by Jackson and Randall were of embryonic avian bone, and the absence of preferred orientation in such young bones is in accord with results we have obtained with X-ray diffraction.

We have examined the femora of rats from birth onwards, and find that there is no preferred orienta-

tion of the inorganic crystals until the rats are approximately three days old; after three days, the orientation increases until at about thirteen days old the orientation is as marked as in adult bones. Golden hamsters gave a similar result, but in guinea pigs orientation was present at birth.

We have, in addition, examined a series of human femora from approximately two months intra-uterine development to old age. At birth human femora show marked orientation; but with fœtal bones there is no orientation before approximately four months intra-uterine development.

It appears, therefore, that the first inorganic crystals which are laid down in bone are randomly orientated, and that there is a definite stage in the early growth at which preferred orientation appears. More detailed information on the above results is being published elsewhere[2].

A parallel investigation on the effect of age on the orientation of collagen fibres in decalcified bone gave some slight indication that the degree of orientation tended to increase with age, but the results were not conclusive. On the other hand, collagen from another source, human chordæ tendineæ, gave definite results which showed that the degree of orientation, as revealed by X-ray diffraction, does change with age. The specimens examined ranged in age from fourteen months to eighty-one years. The X-ray diffraction pattern from the youngest specimen shows only three diffuse continuous rings; at three years the degree of orientation is quite marked, and the adult specimens give a typical, well-orientated collagen pattern similar to that of adult rat tail tendon.

We are indebted to many colleagues in the Pathology and Physiology Departments of this University for providing us with specimens.

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Real and Apparent Absorption Coefficient of Ultrasonic Waves in Liquids

IT has been suggested that the generally accepted high absorption coefficient of ultrasonic waves[1] in carbon disulphide and also, to some extent, in benzene, are not in accord with some experimental observations made by us[2]. This problem has now been studied more critically.

For this purpose, three thermostatic trap-vessels, with thin mica windows on opposite sides, having inside path-lengths of 1 cm., 3 cm. and 5 cm., were used. The front surface of any of these vessels was placed at either of the distances 5·5 cm. or 15·5 cm. from the vibrating quartz, oscillating at 3 Mc./sec. and with 90 W. as the power input, in a long temperature-controlled metallic vessel containing toluene. An absorber was placed at the farthest end.

Table 1

Liquid in trap	Length of vessel x'	Observed wattage I_m at distances from Q: $x=5{\cdot}5$ cm.	$x=15{\cdot}5$ cm.	Mean I_{m_1}/I_{m_2}	Energy abs. coeff. β	$\alpha/\nu^2\times10^{17}$
Toluene	1 cm.	0·42	0·33			
"	3 cm.	1·03	0·78	1·28	0·0247	137
"	5 cm.	1·59	1·27			
Carbon disulphide	1 cm.	1·32	0·88			
" "	3 cm.	1·72	1·11	1·55	0·0438	244
" "	5 cm.	1·90	1·20			
Benzene	1 cm.	0·72	0·50	1·45	0·0385	205
"	5 cm.	2·11	1·44			

The rise of temperature, due to absorption of ultrasonic energy in the trap vessels, in equilibrium condition, containing either toluene, carbon disulphide or benzene, was noted. The equivalent electrical wattage to generate the same rise of temperature was determined by electrical heating. Stirring was by ultrasonic waves. The recorded wattages at the two positions, for different vessels with different liquids, are given in Table 1.

The general relationship to determine the relevant quantities may be written:

$$I_m = I_0 \exp(-\beta x)\{1-\exp(-\beta' x')\} = I_i\{1-\exp(-\beta' x')\}$$

where I_0, I_i, I_m measure the ultrasonic energy at the quartz, incident at the trap vessel and inside the trap vessel, respectively; β and β' measure the energy absorption coefficients of the outside and the inside liquid; x,x' measure the distances from quartz to vessel and that inside the vessel respectively. The I_m ratio for a particular vessel with a particular liquid, for two different values of x, gives us the β-value for the outside liquid toluene and hence the value of α/ν^2 for toluene.

It will be observed that the value of the measured absorption coefficients for the outer liquid toluene varies, if not with the vessel size, definitely with the liquid in the trap vessel, which is rather unexpected. Further, it may be noted from the observations that the absorption coefficient β' of the liquid inside, obtained from measurements of I_m for two vessels placed at any particular values of x, changes curiously with the pair of sizes chosen and also, perhaps, with the chosen value of x.

The absorption coefficient of toluene, obtained with a 1-cm. trap-vessel containing also toluene, is in fair agreement with the usually accepted value obtained by other methods. Let us assume that the corresponding data measure the phenomenon considered correctly. As shown in Table 1, it is found that $\beta = \beta' = 0{\cdot}0247$ and $I_m = 0{\cdot}42$ W., when $x = 5{\cdot}5$ cm. and $x' = 1$ cm. From the general relationship we have, immediately, $I_i = 16{\cdot}8$ W. and $I_0 = 19$ W., which is about 20 per cent of the input energy. With these values of the incident energy I_i and β, the expected wattages at the near position for the larger vessels are 1·2 and 1·9 W., respectively, which are little larger than the measured values. Somehow, the energy of absorption in larger vessels has become slightly reduced.

The measured wattage, I_m, with carbon disulphide in the 1-cm. trap-vessel, at the nearer position, gives, with the same value of I_i, the relation $1{\cdot}32 = 16{\cdot}8\{1-\exp(-\beta'.1)\}$. This gives $\alpha/\nu^2 = 444\times10^{-17}$ for carbon disulphide. Similarly for benzene, we have $\alpha/\nu^2 = 240\times10^{-17}$. With this absorption coefficient the expected wattages, at the near position,

with larger vessels containing carbon disulphide, are 3·6 and 5·5 W., showing a larger reduction of measured values than for toluene. With the usually accepted high value of α/ν^2 for carbon disulphide and benzene, the values of I_m would be 11 W. and 2·5 W., instead of about 1 W. and 0·7 W. observed.

On the other hand, with liquid carbon disulphide in the outer vessel, one obtains practically no energy in the trap-vessel, in the near position, indicating a very high absorption coefficient apparently, in accordance with the high value obtained by other methods. Accurate measurements of rise of temperature are, however, not possible under these conditions, the temperatures on the different sides of the vessel reaching different values. The rise of temperature outside the trap-vessel is, on the whole, too small to indicate a large absorption coefficient.

To test this point directly, the rise of temperature due to the same ultrasonic source was measured in liquid carbon disulphide in a long glass vessel, so that practically no energy is likely to be reflected. The rise was found to correspond to 1·5 W. only, from a comparison with electrical heating. This is in correspondence with the low wattage measured in a 5-cm. trap-vessel, which requires a low absorption coefficient. The high input ultrasonic energy is not found to be absorbed as internal energy, degenerating into heat.

It is clear from the above that the ultrasonic energy in carbon disulphide is dissipated in other ways than internal absorption. In seeking other possibilities it was found, by putting lycopodium powder in the liquids, that a strong turbulent motion is set up in carbon disulphide by ultrasonic waves; a rather smaller turbulent motion is also observed in benzene and toluene. It is considered that the effective dissipation of energy in carbon disulphide and also in benzene is due to turbulent motion. A measure of the generating energy of turbulence is given[3] by the expression $\rho u^3 a^{-1}$, where u is the vertical component of velocity. Although accurate measurements of this velocity component were not possible, a rough check indicates that the proportion of the energy of turbulence is of the order of the proportion of missing energies.

We suggest, therefore, that the drop in measured ultrasonic wattages in the trap-vessels is due to dissipation of vibration energy to turbulent motion developed. The dissipation appears to be more effective with larger vessels, which allow the development of turbulent motion; the energy of turbulence appears to be transmitted through the window. The small turbulence observed with toluene indicates that the absorption measured by displacement is not due to conversion to internal energy only. This would lower the assumed real absorption coefficient of toluene, and thus also for the whole set of observations. On the other hand, if turbulence has developed from vibratory motion in a small vessel, which appears to be probable at least for carbon disulphide, the real absorption coefficient would be correspondingly increased from the value calculated above.

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Non-Isothermal Membrane Potentials

Although the measurement of isothermal membrane potentials has received considerable attention, we know of no previous work in which the e.m.f. of a membrane-cell has been measured when the two halves of the cell are at different temperatures. Application of the methods of the thermodynamics of irreversible processes to a system consisting of two half-cells separated by a membrane yields the following equation for J_i, the flux of the ith component, through the membrane:

$$J_i = \sum_k L_{ik}\{+\bar{V}_k\,\mathrm{d}P + Q_k^*\,\mathrm{d}\ln T + RT\,\mathrm{d}\ln a_k + e_k\,\mathrm{d}\psi\} \quad (1)$$

where the L_{ik}'s are the phenomenological coefficients obeying the Onsager reciprocal relations, $L_{ik} = L_{ki}$, $\bar{V}_k$ is the partial molar volume of the kth species, Q_k^* its heat of transfer, e_k ($= z_k F$) the charge, including sign, per mole of the kth species, and $\mathrm{d}P$, $\mathrm{d}T$, $\mathrm{d}\mu_k$ ($= RT\ \mathrm{d}\ln a_k$) and $\mathrm{d}\psi$ the differences in pressure, temperature, chemical potential of the kth species and electrical potential, between the two half-cells. If the half-cells are well stirred, the values of these parameters are uniform throughout each half-cell and all the above differences occur across the membrane. Previous theoretical treatments[1,2] have neglected the possibility of temperature as a variable, treating only the isothermal case.

The interrelationship of the various phenomena which may be studied with the view of testing the predictions of the theory is illustrated in Fig. 1. The energy flux, J_u, is normally of no interest but is included for completeness.

The complete examination of even a single membrane system would entail a long research programme; for the present[3], we have concentrated on the measurement of membrane potential, thermal diffusion potential, transport number, electrical conductance, electro-osmosis and self-diffusion coefficient, using homogeneous membranes of cross-linked polymethacrylic acid.

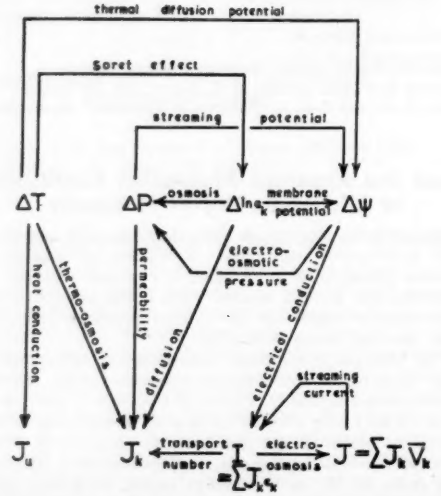

Fig. 1

Substituting from (1) in the relation:

$$I = \sum_k J_k c_k \qquad (2)$$

and utilizing the definitions of electrical conductance:

$$G = \left(\frac{I}{\mathrm{d}\psi}\right)_{\mathrm{d}P = 0,\ \mathrm{d}T = 0,\ \mathrm{d}\ln a_k = 0} \qquad (3)$$

and reduced transport number:

$$t_k = \left(\frac{FJ_k}{I}\right)_{\mathrm{d}P = 0,\ \mathrm{d}T = 0,\ \mathrm{d}\ln a_k = 0} \qquad (4)$$

yields the expression for the potential difference:

$$\mathrm{d}\psi = + \frac{I}{G} - \frac{1}{F}\sum_k t_k\,(\bar{V}_k\,\mathrm{d}P + Q_k^*\,\mathrm{d}\ln T + RT\,\mathrm{d}\ln a_k) \qquad (5)$$

An equation of this form but without the temperature term has been obtained by Kirkwood[2], who regarded the membranes as a continuous system. At zero current, when $\mathrm{d}P = 0$, $\mathrm{d}\ln a_k = 0$, equation (5) becomes:

$$\mathrm{d}\psi = -\frac{1}{F}\sum_k t_k\,Q_k^*\,\mathrm{d}\ln T \qquad (6)$$

Since it is only possible to measure the e.m.f. of a membrane cell, the temperature coefficient of the reversible part of the cell e.m.f., $\mathrm{d}E_{\mathrm{rev.}}/\mathrm{d}T$, must be added to $\mathrm{d}\psi/\mathrm{d}T$ to obtain the complete expression for the temperature coefficient of the membrane cell, $\mathrm{d}E/\mathrm{d}T$. Neglecting contact potential differences and the thermo-electric effect in the cell terminals, this expression is:

$$\frac{\mathrm{d}E}{\mathrm{d}T} = \frac{\Delta S^\circ}{F} + \frac{R}{z_i F}\ln a_i + \frac{RT}{z_i F}\frac{\mathrm{d}\ln a_i}{\mathrm{d}T} - \sum_k \frac{t_k Q_k^*}{FT}$$

where z_i is the charge, in units of e, on the ith species, to which the electrodes are considered to be reversible. Unfortunately, because of the impossibility of measuring heats of transfer of single ions, and of the uncertainties regarding conventional[4] entropies of single ions which preclude the evaluation of the entropy change for the electrode reaction, ΔS°, a complete experimental test of this equation is not possible. A complete derivation of these equations and experimental results will be published elsewhere.

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Optical Rotation of the Isomeric Trehaloses

Molecular rotation of any glycoside containing an optically active aglycone is equal, according to Klyne[1], to the sum of the molecular rotations of the corresponding methylglycoside and aglycone. This rule has been used successfully many times for the calculation of molecular rotations of the glycosides containing steroid substances as aglycones[2], later for the calculation of molecular rotations of glycoalkaloids[3]. Hitherto, this rule has not been used for calculations of molecular rotations of disaccharides, which can also be considered as glycosides. Some complications are to be expected, as a disaccharide, containing two hexosepyranoid units, can exist in at least eleven isomers which differ in their values of specific and molecular rotations. The contribution of the aglyconic part of the molecule will influence the molecular rotation of the whole molecule in an unknown fashion.

The calculation of molecular rotation of the non-reducing disaccharides is possible on the assumption that both parts of the molecule are equivalent; then one can use two values of molecular rotation of the methylglycosides in question, in order to replace the value of the aglyconic part by the value of the methylglycoside. For the calculation of molecular rotations of the three isomeric trehaloses the following values of the methyl-D-glucosides were used:

	$[\alpha]_D$	$[M]_D$
Methyl-α-D-glucopyranoside (H_2O)	+ 158·9°	+ 38·860°
Methyl-β-D-glucopyranoside (H_2O)	− 34·2°	− 6·640°
Tetra-O-acetyl-methyl-α-D-glucopyranoside ($CHCl_3$)	+ 130·5°	+ 47·280°
Tetra-O-acetyl-methyl-β-D-glucopyranoside ($CHCl_3$)	− 18·2°	− 6·590°

For the three isomeric trehaloses the following values were obtained (that is, the sum of the values of the two methyl-D-glucosides); these are compared in Table 1 with the values calculated by Hudson[4] and those found experimentally.

With the exception of the values calculated for the α,α-trehalose, the coincidence with the other values is very good; rather better than those of Hudson, which differ very much in the case of the isotrehalose. It is interesting that the calculations for the neotrehalose agree very well with the values found for the less positive products.

Another calculation was carried out for the $[\alpha]_D$ of α-D-galactopyranosyl-β-D-galactose; the calculated value, + 111°, does not agree, however, with the

Table 1

	Calculated according to			Found experimentally	
	Klyne		Hudson (ref. 4)		
	$[M]_D$	$[\alpha]_D$	$[\alpha]_D$	$[\alpha]_D$	Ref.
α-D-Glucopyranosyl-α-D-glucopyranose α,α,-Trehalose	+61·720°	+180·5°	—	+178°* +197·1°	5 5
Octaacetate	+94·560°	+139·3°	—	+162·5°	6
α-D-Glucopyranosyl-β-D-glucopyranose α,β-Trehalose (neotrehalose)	+24·220°	+ 70·8°	+ 70°	+ 67·1° + 70° + 95°	7 8 9
Octaacetate	+40·690°	+ 59·9°	+61°	+ 68·1° + 67° + 64° + 82° + 80°	7 8 8 9 10
β-D-Glucopyranosyl-β-D-glucopyranose β,β-Trehalose (isotrehalose)	−13·280°	− 38·5°	−58°	− 41·5°	11–13
Octaacetate	−13·180°	− 19·4°	−40°	− 18·6° − 17·2° − 19°	11–13 14 10

* The value given for the dihydrate.

values found experimentally[7], + 67·6° and[8] + 56°. The calculated value for the octaacetate of the compound mentioned above, + 63·4°, does not agree with the value found experimentally[7,8], + 51·7° and + 58°.

For any other calculations of this kind, experimental values are lacking.

A very similar calculation was used, several months ago, with complete success, for the calculation of $[\alpha]_D$ of saccharose and isosaccharose.

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Occurrence in Butterfat of *n*-Heptadecanoic Acid (Margaric Acid)

ALTHOUGH it was formerly assumed that the saturated and unsaturated fatty acids which comprise butterfat were straight-chained and possessed an even number of carbon atoms[1], recent work has established that both branched-chain saturated acids and *n*-odd-numbered acids are also present. Of the saturated odd-numbered acids, *n*-undecanoic acid has been identified in hydrogenated butterfat, while *n*-tridecanoic and *n*-pentadecanoic acids have been shown to occur in butterfat which has not been subjected to hydrogenation. In this communication the isolation is reported from unhydrogenated butterfat of *n*-heptadecanoic acid (margaric acid). Margaric acid has not previously been reported as a component of butterfat, although work in this laboratory has shown it to be present in mutton fat, in shark liver oil, and in hydrogenated ox perinephric fat. It has also been found in the free fatty acid fraction of human hair fat[2]. James and Martin[3] recently reported that their gas–liquid chromatographic analyses indicated the probable presence of margaric acid in goat milk fat.

The bulk sample of butterfat (*B*/36, 37; wt. 36·66 kgm.) used for the work reported in this communication was investigated by means of molecular distillation of the mixed methyl esters, fractional distillation of the resulting concentrates in a 'Vigreux' column, followed by refractionation of individual fractions in a packed column. Fractions with constants ranging between those of methyl palmitate and methyl stearate were bulked together and refractionated in a highly efficient spiral column. Purification was then effected by repeated low-temperature crystallization of the corresponding acids from acetone and from ether.

The following chemical and physical properties of the fraction isolated (*Y2S10S*, wt. 13·20 gm.) establish it as *n*-heptadecanoic acid: melting point, 61·1–61·3° (reported melting points[4]: 61·3°; 61·1°); when mixed with pure margaric acid (melting point 61·1–61·2°) it gave melting point 61·1–61·4°; saponification equivalent 269·6 (calc. for $C_{17}H_{34}O_2$, 270·4); combustion analysis (carried out by Dr. A. D. Campbell, Chemistry Department, University of Otago, Dunedin, New Zealand), C, 75·7; H, 12·7 per cent (calc. for $C_{17}H_{34}O_2$: C, 75·5; H, 12·7 per cent); iodine value 0·0; X-ray long-spacing of sample crystallized from benzene, 39·6 ± 0·5 A. (reported values[4]: 40·45 A., 40·3 A.,; 40·05 A. [5]); methyl ester, melting point 28·9–29·3° (reported melting point[1], 29·7°); n_D^{40} 1·4348. As is characteristic of odd-numbered long-chain normal fatty acids, fraction *Y2S10S* shrinks from the wall of its containing glass vessel.

We are much indebted to Dr. G. G. Claridge, of the Soil Bureau, Department of Scientific and Industrial Research, Wellington, New Zealand, for the X-ray diffraction measurement reported in this communication.

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Excretion Equations and Interpretation for Digitoxin

THE recent communications of Stern[1], and Hough, Barnard and Bassir[2], have dealt with equations for the mathematical interpretation of experimental urinary excretion data. Approximately exponential excretion appears to be typical of the process for a number of substances taken into the body; and several experimentalists have employed this concept[3–5]. The rate constants which may be determined lend themselves to convenient tabulation or discussion in terms of scalar units[6–8].

An appreciable segment of the urinary excretion curve (also blood or other tissue concentration curves) frequently approximates to the shape of the common die-away curve, defined by the equation:

$$C = C_0 \exp(-kt) \qquad (1)$$

In terms of urinary excretion, after attainment of pseudo steady state diffusion conditions in the body, the terms may be defined as follows: C is amount of unexcreted substance following a single dose; C_0 is apparent maximum amount of excretable substance; k is the specific velocity constant characterizing the elimination process; and t is time.

Straight-line graphical evaluation of k is accomplished by putting equation (1) in its logarithmic form:

$$\log C = -\frac{kt}{2{\cdot}303} + \log C_0 \qquad (2)$$

It may be shown that a plot of the change in C for each equal increment of t is also a straight line having the same slope as equation 2. This follows from the fact that, from the differential form of the first-order rate equation, we may write :

$$C = \frac{dC}{dt}\,\frac{1}{(-k)} \qquad (3)$$

Substituting this value of C into equation (2), we obtain :

$$\log \frac{dC}{dt} = \frac{-kt}{2{\cdot}303} + K \qquad (4)$$

Whereas equations (1) and (2), when applied to urinary excretion data, require a knowledge or determination of the amount of drug entering the tissues and the magnitude of maximum excretable substance in order to determine k, equation (4) does not. It requires a knowledge of the amount of substance excreted in a series of reasonably equal time-intervals, where the latter preferably are somewhat less than the biological half-life of the drug[8]. This equation and its applications to the calculations of disappearance rates of substances or drug activities from the tissues would appear to be useful especially following oral doses where the degree of absorption is unknown ; also where bioassay is required and may measure active products of biotransformation.

The application of equation (4) is illustrated in Fig. 1 with the bioassay data of Friedman, Bine, Byers and Bland[9], describing the average urinary excretion of digitoxin and its active derivatives from thirteen human subjects receiving a single oral 1·2 mgm. digitalizing dose of digitoxin. Though this procedure is not a rigorously correct mathematical application of equation (4), its use in this manner constitutes, under the conditions of the study, a rather good approximate evaluation of the total disappearance rate for digitoxin activity.

The graph indicates an apparent biological half-life of approximately 5·3 days corresponding to k of about 13 per cent/day. One may estimate the total average urinary digitoxin-equivalent excretion of the subjects by adding the values of the activities excreted per day, until the process is virtually terminated. When this is done for the data in Fig. 1, slightly more than 40 per cent of the activity of the original dose may be accounted for in the urine. The remainder of the activity possibly is lost primarily through metabolism.

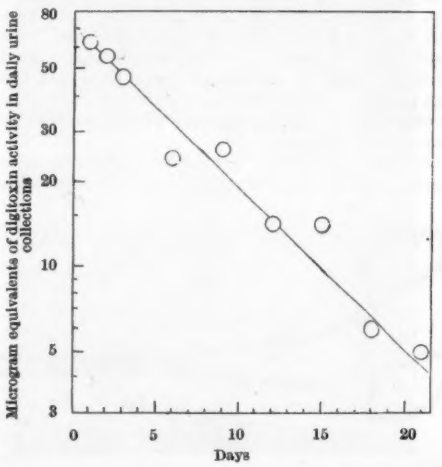

Fig. 1. Average daily urinary excretion of digitoxin activity for thirteen subjects after single oral dose of 1·2 mgm. Data from ref. 6

A logical interpretation of the meaning of the rate-constant suggests that about 13 per cent of the digitalizing dose is dissipated within one day, 13 per cent of the remaining dose the next day, etc. For a 1·2 mgm. dose, this implies that activity corresponding to a 0·16 mgm. oral dose is lost during the first day. The usual daily adult dose for maintaining digitalization generally varies between 0·10 and 0·20 mgm. of digitoxin. The calculations applied to these data may afford a theoretical rationalization of a well-established dosage regimen.

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Dr. J. Swintosky has made a valuable addition to the literature of urinary excretion equations by enabling a specific velocity constant, k, to be derived from the rate of urinary excretion. The meaning of k is not discussed and superficially it appears to depend only on excretion. Our work on inulin has shown us that this is not the case, and it appears useful to give a more general derivation of Swintosky's equation (4) and also to assign a physical meaning to the constant K of that equation.

If the quantity of substance excreted, U, is to show a simple exponential growth curve, then the rate of elimination by other processes must also be directly proportional to the quantity of substance, C, still not eliminated. Mathematically,

$$\frac{dC}{dt} = -(k_1 + k_2)\,C\,; \quad \frac{dU}{dt} = k_1 C \qquad (1)$$

where k_1 and k_2 are the specific velocity constants for excretion and the other processes of elimination. Integration yields

$$U = \frac{k_1 C_1}{(k_1 + k_2)}\,[1 - \exp\{-(k_1 + k_2)t\}] \qquad (2)$$

where C_1 is the quantity of substance to be eliminated. In simple cases C_1 will be the quantity of drug administered ; but in many cases it will be less, as drug absorption may be incomplete, particularly after oral administration.

The maximum value of U, Swintosky's C_0, is

$$C_0 = \frac{k_1 C_1}{k_1 + k_2} \qquad (3)$$

From equation (2) is obtained

$$\log \frac{dU}{dt} = -\frac{(k_1 + k_2)t}{2{\cdot}303} + \log k_1 C_1 \qquad (4)$$

which is the equivalent of Swintosky's equation (4). Thus

$$k = k_1 + k_2\,;\; K = \log k_1 C_1 = \log kC_0 \qquad (5)$$

Swintosky's specific velocity constant, k, is seen to depend on all processes of elimination in the same manner. K enables a value of C_0 to be found and, used with C_1 and k, enables k_1 and k_2 to be estimated.

In fact, it is not possible to measure the rate of excretion, but only the average value, E, over a period, T. It is not difficult to show that if E is used instead of dU/dt, K becomes:

$$\log \frac{C_0}{T}\{1 - \exp(-kT)\} \qquad (6)$$

If the data on digitoxin are re-examined in this way, then $C_0 = 580$ μgm.

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Hyperprotection against Radiation by combining Addition of Cysteine with Lyophilization

By the addition of protective agents, such as broth and gelatin, it has become possible to obtain X-ray survival curves for phages in solution which are the same as those obtained from dry phages[1], thus making it possible to interpret the results as being due to direct hits of the radiation on the phages. This attractive possibility has been rendered tenuous by the finding of hyperprotection by irradiating at low temperatures[2] or by irradiating in the presence of agents such as cysteine[3]. Both these devices decrease the slope of the survival curves by a factor of about 1·4. The purpose of this communication is to present a technique which decreases the slope of the survival curve by a factor of about 2·5.

*T*2 coliphages in 4 per cent broth were frozen by being dropped into an aluminium cup standing in 'dry ice', and were irradiated with 100 kV. X-rays (half-value layer 2·0 mm. aluminium) while at 'dry-ice' temperature. The cups were then placed in pre-cooled test-tubes standing in a salt – ice bath (about − 20° C.) and pumped through a manifold and a trap by a 'Highvac' pump. The preparations are pumped for 4–5 hr., which is about twice as long as needed to make them dry, as judged by eye. The preparations were reconstituted by being dropped into broth at room temperature and are then assayed.

The results of twelve experiments with broth and sixteen with 0·15 *M* cysteine added to the broth are given in Table 1. The survival due to other treatments is also given, by way of control experiments. That the increased survival is not due to the combination of the effects of cysteine and low temperature is clear, because preparations treated this way, but not dried, show a markedly smaller increase of survival.

Table 1. Fractional Survival of *T2r* at Various X-Ray Doses (10,000 R./min.)

	0 min.	12 min.	24 min.
Broth solution at 0° C.	1·00	0·061	0·0041
Frozen, irradiation at − 78° C. in broth	1·00	0·091	0·010
Frozen, irradiation at − 78° C. in broth plus 0·15 *M* cysteine	1·00	0·11	0·017
Frozen, irradiation at − 78° C. in broth, dried at − 20° C.	1·00	0·093	0·014
Frozen, irradiation at − 78° C. in broth plus 0·15 *M* cysteine, dried at − 20° C.	1·00	0·42	0·10

The added effect due to the presence of cysteine is very probably not due to increase of concentration of cysteine due to sublimation, because the concentration used gives maximal protection in non-frozen solutions. Accordingly, we have tentatively adopted the postulate that the protective action may be due to irradiated cysteine, which could be expected to be concentrated by the sublimation. If this postulate is adopted, the experiments offer evidence that the mechanism of protection is that of repair of damage to the phages, because the concentrated protector should be unable to get to the phages until the samples are again in solution; this is long after the radiation has done its damage.

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A Technique for One-Stage Bilateral Adrenalectomy in the Rabbit

Reports of total adrenalectomy in the rabbit are indeed few in number[1]. In general, bilateral adrenalectomy in this species has been accomplished in two stages and has been attended by high mortality. We have been impressed by the desire of many investigators to utilize the totally adrenalectomized rabbit in experimental studies and with the fact that this desire has often been frustrated because of technical difficulties following one-stage adrenalectomy. Most workers are able to remove the left adrenal with ease, but attempts to excise the right adrenal gland, even at the hands of a skilled surgeon, often result in fatal hæmorrhage from the vena cava. This occurs because the capsule of the right adrenal is connected to the adventitia of the inferior vena cava in this species.

The purpose of this communication is to present a technique for one-stage bilateral adrenalectomy in

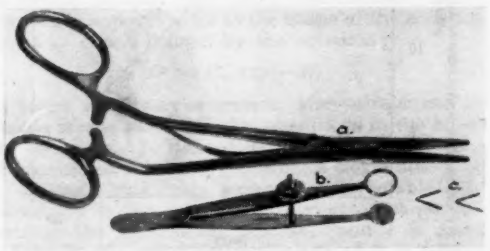

Fig. 1. Essential instruments for total one-stage adrenalectomy: (*a*) McKenzie brain clip applying forceps; (*b*) chalazion forceps; (*c*) silver clips

the rabbit which has been developed in our laboratories and which can be performed by unskilled operators with an overall mortality of less than 10 per cent. Actually, in our studies of the role of the adrenal gland in infection and intoxication in the rabbit, we have performed total one-stage adrenalectomies in more than five hundred rabbits by this technique. The method is simple and rapid, and should be of value to anyone wishing to study the adrenalectomized rabbit.

The necessary instruments are sterilized and kept under aqueous zephiran (1 per cent). The three essential instruments include the chalazion forceps, the McKenzie brain clip applying forceps and neurosurgical-type silver brain clips specially designed for this purpose (Fig. 1).

Adequate pre-operative preparation of rabbits consists of intramuscular injections of 25 mgm. cortisone, 5 mgm. deoxycorticosterone acetate, and 250,000 units aqueous penicillin, one or two hours prior to surgery. Nembutal anæsthesia is given intravenously in a dosage of 0·4 c.c. per kgm. but not exceeding 1·2 c.c.; the required depth of anæsthesia is then completed by cautious administration of ether, by cone.

A generous ventral incision is performed under sterile conditions, after careful shaving and preparation of the skin, and extends from the xiphoid to the level of the iliac crests. The intestines are carefully displaced and enclosed in sterile towels soaked with warm isotonic saline, revealing the right renal area. The renal fascia is incised around the borders of the right kidney, and the latter is reflected medially to obtain exposure of the right adrenal bed. Dissection of the right adrenal gland is accomplished by use of a blunt probe and is facilitated by ligation of the lumboadrenal vein as it enters the inferior vena cava, and the use of saline-soaked sponge in keeping liver

Fig. 2. Silver clip in place. Right adrenal gland enclosed in chalazion forceps, readied for excision by sharp dissection between forceps and clip

Fig. 3. Right adrenal excised, right kidney replaced, clip in place

lobes from the field. Careful dissection of the superior and inferior poles of the right adrenal allows complete enclosure of the gland in the chalazion forceps. The neurosurgical clip is then applied as shown, so as to include a minimum portion of vena cava immediately adjacent to the adrenal gland (Fig. 2). The adrenal gland is then excised by sharp dissection between the chalazion forceps and the clip (Fig. 3). The excised gland is examined at this time for completeness of the adrenal capsule; if the latter has been interrupted, the animal is discarded, since we have found that when any portion of the capsule is left behind, the glandular tissue readily regenerates. The right kidney is then replaced, and the left adrenal is similarly approached. Use of the silver clip is not absolutely necessary on the left side, but is a convenience. Closure is accomplished in layers, using 000 or 0000 silk.

When well practised, the procedure requires approximately fifteen to twenty minutes per rabbit. The principal difficulty encountered is hæmorrhage at the right adrenal site due to inadequate or poor apposition of the neurosurgical clip surfaces (these clips are similar to the hæmostatic silver clips used by the neurosurgeon, but are somewhat longer, being 1 cm. in length; they are prepared locally from silver wire by our scientific apparatus shop. The McKenzie forceps are specially grooved to fit clips of this size). The mortality at surgery is, however, reducible to less than 5 per cent. In our experience, anatomically identifiable accessory adrenal tissue is present in less than 1 per cent of the rabbits of the stock we have been using.

Post-operative requirements include frequent changes and replenishment of water containing sodium chloride and sodium bicarbonate, and strict attention to cleanliness, constant temperature, and minimum handling in the animal quarters.

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Thyrotrophic and Gonadotrophic Hormone Contents of Pituitaries and Blood of Dogs during the Winter and Summer

Sixteen mature mongrel dogs were used in this experiment. They were obtained from the Isolation Hospital at Abbassia, Egypt. Three males and five females were obtained during the summer (August); four males and four females were obtained during the winter (January). The females were anœstrous, non-pregnant and non-lactating. The pituitaries of the dogs of the same sex and season were pooled, and equal parts of the plasma of individuals of the same group were also pooled.

The thyrotrophic and gonadotrophic hormone contents of the pituitaries and blood were determined by the use of the chick assay method[1]. Groups of chicks corresponding to each of the dog groups were given daily doses of either 1 mgm. pituitary in 0·5 ml. of saline or 1 ml. of plasma for four days. The weights of the chick thyroids indicated the level of thyrotrophic hormone, and the weights of the testes the level of gonadotrophic hormone.

The results obtained are shown in Tables 1 and 2. From these findings it appears that the thyrotrophic and gonadotrophic hormone contents of the pituitaries are not altered by season. Similar results were obtained in studies with the ewe[2]. The rate of production of these hormones, however, is altered by seasonal variations, as indicated by their level in the blood.

Table 1. Thyrotrophic and Gonadotrophic Hormone Contents of Dog's Pituitaries as Indicated by Weights of Thyroid and Testes of 1-day-old Male Chicks

Season	Sex of dogs	No. of chicks	Thyroid wt. (mgm./100 gm. body-wt.)	Testes wt. (mgm./100 gm. body-wt.)
Summer	Male	5	6·57 ± 2·01*	39·10 ± 10·71
	Female	8	12·94 ± 1·38	41·28 ± 6·81
Winter	Male	6	8·13 ± 0·59	30·68 ± 4·09
	Female	5	16·31 ± 1·11	40·51 ± 7·97
Control chicks	—	9	5·27 ± 0·37	25·17 ± 3·12

* Standard error.

Table 2. Thyrotrophic and Gonadotrophic Hormone Contents of Dog's Blood as Indicated by Weights of Thyroid and Testes of 1-day-old Male Chicks

Season	Sex of dogs	No. of chicks	Thyroid wt. (mgm./100 gm. body-wt.)	Testes wt. (mgm./100 gm. body-wt.)
Summer	Male	4	6·20 ± 0·32*	38·51 ± 3·93
	Female	4	10·37 ± 0·52	31·82 ± 6·17
Winter	Male	7	10·77 ± 0·90	22·14 ± 2·20
	Female	6	15·70 ± 1·60	27·03 ± 1·56

* Standard error.

The thyrotrophic hormone content of the blood was higher during the winter than during the summer, both in male and female dogs. The level of gonadotrophic hormone in the blood tends to rise during the summer as compared to the winter level. These differences proved to be statistically significant.

The gonadotrophic hormone content of the pituitaries of male and female dogs did not show a statistically significant difference; but the thyrotrophic hormone content of the pituitaries and blood of female dogs was significantly higher than that of the males, during both seasons.

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Comparison of Interphase and Prophase in Isolated Rat Liver Nuclei

It has often been found that isolated interphase nuclei can be made granular or homogeneous artificially by alteration of the composition of the medium in which they are suspended[1–3]; and there is an obvious possibility that this is related to the condensed and decondensed states of chromosomes in prophase and interphase respectively, that is, that the change from interphase to prophase is merely a 'granulation' produced by a change in physical properties of the cell sap. The only apparent difference is that artificial granularity in isolated interphase nuclei is of finer texture, that is, the granules are smaller and probably more numerous (though difficult to count) than the chromosomes in natural prophase. A simple explanation of the difference in texture could be based on analogy with crystallization, for example, of proteins, where in some cases fine texture results from too rapid change in the medium. We therefore tried to 'crystallize' chromosomes in isolated interphase nuclei by changing the medium continuously over periods up to a few hours, by dialysis or by drop-wise additions with gentle stirring.

The changes tried, each of which produced granularity when applied suddenly, were increase of ionic strength from 0·03 to 1·03, decrease of *p*H from 7·0 to 5·1, addition of magnesium chloride (0·008 *M*), addition of protamine (0·02 per cent) and addition of histone (0·05 per cent). The result was negative, that is, in no case was the texture noticeably coarser than when the same change had been produced suddenly. This is illustrated by the phase-contrast photographs (Fig. 1), where (*a*) shows a typical isolated nucleus kept in the homogeneous condition (except for the nucleoli) by suspending in a medium similar to that recently described by us[3], which gives a good imitation of the normal interphase appearance inside cells; (*b*) shows a nucleus from part of the same suspension to which ½ vol. of the same medium plus 0·1 per cent histone had been added suddenly; (*c*) shows one from another part to which the histonized medium had been added drop-wise with gentle stirring over a period of two hours; and (*d*) shows a

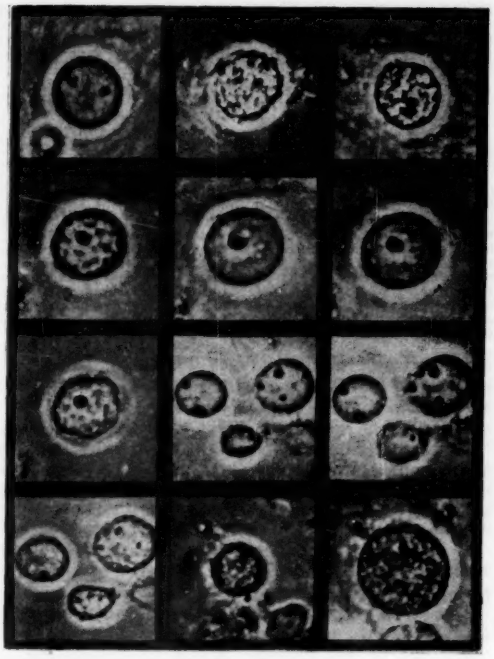

Fig. 1. *a, b, c, d, e, f, g, h, j, k, l, m,* from top left across to bottom right

prophase nucleus, occurring in a suspension of nuclei from regenerating rat liver in the medium used for (*a*). On careful examination, it will be seen that the texture in (*c*) is not noticeably coarser than in (*b*), and that both are finer than the texture in (*d*), suggesting either that the condensation of chromosomes at prophase is more than a mere 'crystallization' of nucleohistone, or that we have not found the right conditions for crystallization. Under the conditions of this experiment there was less tendency for the granularity to be concentrated at the periphery than in the experiments previously described by us[3]. The regenerating liver was produced by 70 per cent hepatectomy two days previously[4]. Condensed chromosomes were found in all three sizes of nucleus which occur in rat liver, diploid (*l*), octoploid (*m*), as well as in the most frequently occurring[5] tetraploid size shown in (*d*).

The crystallization hypothesis is also opposed by the fact that the chromosomes in (*d*) are condensed even though they are in the same normal medium as the interphase nucleus in (*a*), which is homogeneous. It is possible that the interphase nuclei are 'supersaturated' in this medium and will crystallize into condensed chromosomes without change of medium, given time ; but we have not seen this happen during three days. It seems, therefore, that prophase chromosomes are less 'soluble' than interphase ones, which could be due to the possible presence of more histone. We tested this by adding to the prophase nucleus a little potassium triphosphate, which is one of several reagents that can remove histone competitively from its salt-like combination with nucleic acid. This experiment is illustrated in (*d*) to (*g*), where (*d*) is the prophase nucleus in normal medium ; (*e*) is the same nucleus made homogeneous by perfusion on the slide with 0·03 *M* potassium triphosphate ; (*f*) is the same still homogeneous after returning to normal medium ; and (*g*) is the same with the original discrete chromosomes regranulated by addition of 0·01 per cent histone. A group of interphase nuclei from the same preparation is shown for comparison, (*h*) in normal medium, (*j*) in 0·03 *M* potassium triphosphate and (*k*) in 0·01 per cent histone. It is seen that the prophase nucleus became homogeneous as expected, and remained so when returned to normal medium ; but though thus resembling an interphase nucleus it was not identical, because when histone was added it became granular with the original coarse texture, showing that the chromosomes were still in the discrete prophase form.

The above experiment shows that some structural difference between prophase and interphase nuclei persists even when both are homogeneous. It might be, for example, that in interphase the chromosomes are cross-linked to each other by some bonds that are broken in prophase. If these bonds are electrovalent they should be loosened at high ionic strength, possibly just before the loosening of internal bonds which causes nucleoprotein to pass from the homogeneous gel to the sol form and to diffuse out through the nuclear membrane. Experiments on these lines, at ionic strengths up to 2·4, with or without addition of protamine or histone to suppress sol formation, were unsuccessful. Other possible cross-links (which might be present in the non-histone protein to which Mirsky and Ris[6] and Dounce and Monty[7] attach structural importance) are hydrogen bonds or—S—S— bonds as in keratin, but addition of 5 *M* urea, 0·5 *M* potassium thioglycollate and 0·15 per cent histone, which should break these bonds while granulating the interphase nuclei, failed to produce the desired coarse texture.

We conclude that interphase and prophase differ in at least two properties, degree of granularity and fineness of 'latent texture' ('latent' because only observable in the granular state). We can alter the degree of granularity at will by many methods, but all our attempts to alter the fineness of the latent texture have so far failed.

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6-O-Acetylglucose: a New Metabolite formed by a Cobalamin-producing Strain of *Bacillus megaterium*

It was shown by paper chromatography that a cobalamin-producing strain of *B. megaterium* (N.C.I.B. No. 8508) gave a comparatively large amount of a new metabolite. This was a carbohydrate with R_G 0·28 in butanol–water at 30°, reducing ammoniacal silver nitrate and giving a brown colour with aniline phthalate.

In a typical experiment the strain was grown for 4 days at 28° in a medium containing mineral salts and 4 per cent (w/v) glucose (in some cases 0·2 per cent (w/v) 'Difco' yeast extract was added). The centrifuged medium was treated with ion exchange resins to remove inorganic material, evaporated at 30° *in vacuo*, and the metabolite was isolated by chromatography on a cellulose column. The infra-red spectrum showed that the substance was an acetylated glucose with a pyranose ring structure[1]. It crystallized from water as minute prismatic rods with melting point 133° and $[\alpha]_D^{20}$ + 48° at equilibrium (*c*, 4·0 in water). (Elementary analysis gave: C, 43·1; H, 6·29. $C_8H_{14}O_7$ requires C, 43·2; H, 6·35 per cent.) Hydrolysis with acid gave glucose (identified by paper chromatography, by optical rotation and as the osazone, melting point and mixed melting point 211°) and acetic acid (identified by Duclaux numbers, by paper chromatography and by X-ray powder photography of the sodium salt). The hydrolysis products were present in equimolar proportions.

Acetylglucose formed a phenylhydrazone, melting point 134–36°; $[\alpha]_D^{20}$ − 13° (*c*, 1·3 in water) (found: CH_3CO, 12·9; N, 8·6. $C_{14}H_{20}O_6N_2$ requires CH_3CO, 13·8; N, 8·97). The acetyl residue was partly removed under the conditions used to form the osazone and only glucosazone was isolated. With modified conditions a suspected acetylglucosazone was obtained (found: CH_3CO, 9·9; $C_{20}H_{24}O_6N_4$ requires CH_3CO, 10·8) with an infra-red spectrum very similar to that of glucosazone but with an additional band at 5·79μ corresponding to an acetyl carbonyl group.

Acetylglucose did not form a trityl ether under the conditions normally used for reaction at the primary alcoholic group.

Oxidation with periodic acid gave a clear indication of the structure of the acetylglucose. The ester (111·2 mgm.) was treated with the appropriate amount of periodic acid in bicarbonate buffer as described by Reeves[2]. No formaldehyde-dimedon was obtained and other experiments showed that the ester was oxidized to give formic acid.

Bell[3] has indicated that periodate oxidation with production of formaldehyde affords a reliable qualitative test for the presence of free primary hydroxyl groups, and Manson and Lampen[4] have characterized a 2-deoxy-D-ribose 5-phosphate because it failed to yield formaldehyde on oxidation with periodate.

It follows that the new metabolite is 6-O-acetyl-D-glucopyranose. Since it can be produced from a growth experiment in a yield of not less than 20 per cent (on the basis of the total glucose initially used) there is no doubt that it is one of the major products of metabolism of this strain.

A total of fourteen strains of *B. megaterium* have been examined (N.C.I.B. No. 2605, 7581, 8508 and eleven others, obtained by courtesy of Dr. Ruth Gordon, Institute of Microbiology, Rutgers University). Of these, only three produced acetylglucose. Cobalamin production has been reported in the case of ten of the strains[5] and was highest (as was acetylglucose production) with the strain used in this work. A relation between the metabolites is not apparent from the above.

It was shown that resting cells of the organism were able to synthesize the ester from glucose and that pyruvate increased the amount produced in 4 hr. (Table 1).

The results suggest that pyruvate acts as a source of active acetate. The presence of phosphotransacetylase was demonstrated in a cell-free extract (prepared by grinding the cells with alumina[6]) by the method of Stadtman *et al.*[7], suggesting that either acetylcoenzyme *A* or acetyl phosphate could participate in the synthesis.

Table 1. Synthesis of Acetylglucose from Glucose by Resting Cells of *B. megaterium* N.C.I.B. 8508. The Effect of Pyruvate

Time (hr.)	Acetylglucose formed (μmole)	
	Glucose only	Glucose + pyruvate
0	—	—
2	—	13
4	13	37

Filter flasks (100 ml.) were charged with glucose (890 μM) in water (2 ml.), washed cell suspension (4 ml. dry weight 38 mgm./ml. in 0·1 *M* phosphate buffer of *p*H 7·0), and buffer (2 ml.), or sodium pyruvate (1,460 μM) in buffer (2 ml.). Each flask was exhausted, charged with oxygen through the side arm and shaken in a thermostatic bath at 28°. Samples were removed at intervals and cells removed by centrifuging or by passing through a bacterial filter. Acetylglucose was estimated by comparison with a standard on a paper chromatogram with the aid of a Joyce–Loebl recording double-beam reflectance densitometer. The filter flasks were refilled with oxygen after removing each sample. The *p*H remained unchanged at the initial value of 7·0 throughout the experiment.

Details of the above and related work will be submitted for publication elsewhere. We are indebted to Mr. W. A. Mitchell of this Institute for taking the X-ray powder photographs.

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Incorporation of Phosphorus-32 and Mutagenesis during Spermatogenesis in *Drosophila*

Radioactive isotopes may be used as a source of radiation not only for tracing biological processes but also for influencing them. The following is a summary of the results of some experiments utilizing a combination of these two principles, in that the incorporation of radioactive phosphorus has been followed during spermatogenesis in *Drosophila melanogaster*, and at the same time the genetic effect of the radioactive decay of the phosphorus atoms has been measured. The genetic and metabolic effects of the decay of phosphorus-32 have been investigated by several authors in different materials: in *Drosophila*[1–4], in *Habrobracon*[5], and in micro-organisms[6].

In the present experiments, newly eclosed males were fed a single meal of a sugared solution of phosphorus-32. They were then mated daily to an excess of fresh virgin females, some of which were used for measuring productivity and induced sex-linked recessive lethals, and others provided collections of newly ripe sperm in which the radioactivity was measured after fat extraction and hydrolysis as for Feulgen[7]. Results from one typical experiment are presented in Table 1.

The mutation curve obtained from these daily broods and the activity curve for the sperm are presented in Fig. 1. It is seen that the shapes of the

Table 1. Summary of Data from One Experiment with *Drosophila melanogaster* Males fed with Phosphorus-32. One Group (*a*) of 15 ♂♂ were used for Incorporation Measurements and Another (*b*) of 10 ♂♂ for Genetic Measurements. Day 1 Activities in c.p.m. per Male in the Two Groups were 14,200 ± 750 (*a*) and 17,100 ± 1,500 (*b*)

Days	*n* Offspring per ♂ in *b*	*n* Chromosomes tested in *b*	Sex-linked recessive lethals in *b* (per cent)	C.p.m. in ♀♀ in *a*	C.p.m. in ♀♀ per ♂ per c.p.m. in ♂♂ per offspring
1	123·8	599	1·17 ± 0·44	63·1	$1·34 \times 10^{-6}$
2	246·9	1,176	1·79 ± 0·39	46·1	$0·49 \times 10^{-6}$
3	321·4	1,512	0·99 ± 0·26	50·8	$0·42 \times 10^{-6}$
4	161·0	772	2·46 ± 0·56	50·6	$0·83 \times 10^{-6}$
5	131·0	621	2·74 ± 0·66	47·4	$0·95 \times 10^{-6}$
6	97·0	470	4·89 ± 0·99	63·3	$1·72 \times 10^{-6}$
7	27·0	137	10·22 ± 2·58	42·7	$4·17 \times 10^{-6}$
8	21·0	87	3·45 ± 6·19	20·2	$2·53 \times 10^{-6}$

curves are very similar, suggesting some sort of relationship between the two observed phenomena.

At present, the results do not permit any definitive interpretation. The shape of the present mutation curve is somewhat different from the curve obtained after acute irradiation; but it is not known whether this difference should be attributed to the protracted beta-irradiation suffered by the testes in the present experiments, or if there are other causes to be considered.

The close correlation found between incorporation and mutation is, however, intriguing, and one is tempted to suggest the following alternatives:

(1) The mutations are caused by the transmutation of phosphorus-32 atoms incorporated in the genic material, and the correlation between the curves reflects a true causal relationship.

(2) The mutations are caused by radiation emitted from the phosphorus-32 contained in the whole fly, and the correlation reflects a coincidence in time of incorporation activity and mutagenesis.

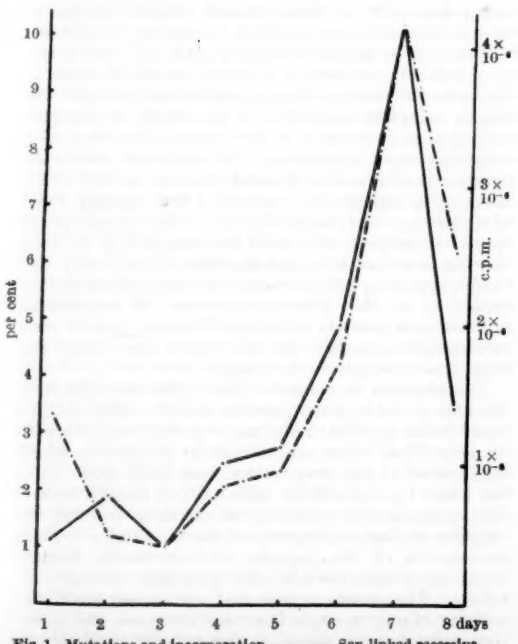

Fig. 1. Mutations and incorporation. ———, Sex-linked recessive lethals in per cent; —.—.—, counts per min. after background in sperm, in males per male per c.p.m., per offspring

If only the first of these alternatives is true, it probably means that all the phosphorus-32 remaining in the sperm and seminal fluid is the phosphorus in deoxyribonucleic acid. It would also mean that the level of radiation from phosphorus-32 in the fly in general is so low that it has very little mutagenic effect.

If only the second alternative is true, it means that there is a correspondence between phosphorus incorporation and sensitivity to the mutagenic action of radiation. If it is permissible to generalize, one might put it that the curves indicate a correlation between synthetic activity—that is, certain aspects of metabolism in general—and radiosensitivity. This might have some bearing on the mechanism of anoxic protection, and also protection through some chemicals, for example, cyanide.

It is hoped that experiments now under way will make it possible to determine to what extent each of these mechanisms is responsible for the genetic effects observed.

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Effect of Carcinogenic Compounds on the Hæmatin-catalysed Oxidation of Unsaturated Fat

Efforts aimed at establishing a biochemical mechanism for carcinogenic action have included studies of the inhibition of unsaturated lipid oxidation by carcinogenic compounds[1]. The hæmatin compounds, particularly hæmoglobin, myoglobin and cytochrome *c*, appear to be the main catalysts of unsaturated lipid oxidation occurring in animal tissues. This reaction has been postulated to be of prime importance in many types of pathological unsaturated fat oxidation *in vivo*[2]. This report presents results of studies undertaken in an attempt to demonstrate what, if any, effects were induced by the presence of certain carcinogenic compounds in *in vitro* hæmatin-catalysed unsaturated fat oxidation systems.

Two different unsaturated fat oxidation systems, a cod-liver oil emulsion and a linoleic acid emulsion, were utilized in this study. The lipid emulsions were prepared by adding 10 ml. of linoleic acid (60 per cent, Nutritional Biochemicals) or 10 ml. of cod-liver oil (iodine number 144, McKesson and Robbins) to 20 ml. of 0·1 *M* phosphate buffer (*p*H 7·0) containing 0·25 ml. of 'Tween 40' (polyoxyethylene sorbitan

monopalmitate). The resulting mixture was passed three times through a hand homogenizer. The carcinogens studied, namely, dimethylaminoazobenzene, *o*-tolylazo-*o*-tolylazo-β-naphthol, 1,2,5,6-dibenzanthracene, 3,4-benzpyrene and 3-methylcholanthrene, were added in the lipid phase. Aliquots of 3·0 ml. of the prepared emulsions were put into the main compartment of Warburg vessels, the side-arm of which contained 1·0 ml. of a 2×10^{-4} *M* hæmatin or a 5×10^{-5} *M* hæmoglobin solution. Following an equilibration period, the contents of the side-arm were mixed with the emulsion, and the rate of oxidation, at 37° C. in the presence of pure oxygen, was measured using conventional manometric techniques. Carcinogen concentration in the final suspension was either 10^{-3} or 10^{-5} *M*.

The rate of oxidation of the hæmoglobin-catalysed linoleic acid emulsions is substantially greater than that of the hæmatin-catalysed cod-liver oil emulsion, although the rate in either case is quite rapid. A short initial induction period of approximately 0·1 hr. was observed in the cod-liver oil system; following this brief induction period, the rate of oxidation was essentially constant over the period of measurement, 1·0 hr. There was no induction period in the case of the linoleic acid systems, but there was a gradual slowing of the rate of oxidation in every case over the 1·0-hr. observation period. Table 1 contains combined results of the two sets of experiments.

Table 1. Effect of Carcinogenic Compounds on the Rate of Oxidation of Hæmatin-catalysed Unsaturated Fat Oxidation Systems

Cod liver oil emulsion : carcinogen added	Oxidation rate (ml. oxygen/hr.)
None	1·2
10^{-3} *M* Dimethylaminoazobenzene	1·1
10^{-4} *M* Dimethylaminoazobenzene	1·4
10^{-3} *M* *o*-Tolylazo-*o*-tolylazo-β-naphthol	1·0
10^{-4} *M* *o*-Tolylazo-*o*-tolylazo-β-naphthol	1·4
Linoleic acid emulsion : carcinogen added	**Oxidation rate (ml. oxygen/hr.)**
None	2·3*
10^{-3} *M* 1,2,5,6-Dibenzanthracene	2·3*
10^{-5} *M* 1,2,5,6-Dibenzanthracene	2·3*
10^{-3} *M* 3-Methylcholanthrene	2·6*
10^{-5} *M* 3-Methylcholanthrene	2·3*
10^{-3} *M* 3,4-Benzpyrene	2·3*
10^{-5} *M* 3,4-Benzpyrene	2·2*

* Average rate for 1-hr. period.

Table 1 shows that the effect of the azo dyes studied on the rate of oxidation of the cod-liver oil system is dependent upon concentration. Both dimethylaminoazobenzene and *o*-tolylazo-*o*-tolylazo-β-naphthol had a very slight antioxidant activity at concentrations of 10^{-3} *M*, while at concentrations of 10^{-5} *M* a more pronounced, pro-oxidant effect was observed, the rate of oxidation being increased by slightly more than 20 per cent. In the case of the linoleic acid emulsion systems, the presence of 1,2,5,6-dibenzanthracene or 3,4-benzpyrene in either concentration had essentially no effect on the rate of oxidation. Similarly, 10^{-5} *M* 3-methylcholanthrene did not affect the rate of oxidation of these systems. However, in the presence of the higher concentration of 10^{-3} *M* 3-methylcholanthrene, the rate of oxidation of the hæmoglobin-catalysed linoleic acid emulsions was increased.

The results of these experiments indicate that in unsaturated fat oxidation systems catalysed by hæmatin compounds, there is no pronounced anti-oxidant effect exerted by several important carcinogenic agents. There are, indeed, stronger indications that these carcinogenic compounds affect such fat oxidation systems pro-oxidatively. These carcinogenic compounds probably react with the free radical lipids produced in hæmatin catalysis to form relatively stable, free-radical carcinogenic compounds. Because they are less reactive and form less stable free-radicals than do polyphenolic antioxidants, and because of the large initiation reaction of hæmatin catalysis, these carcinogenic compounds do not inhibit. Their pro-oxidant effect suggests they enter into the propagation of lipid oxidation and are co-oxidized.

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Evidence for a Mechanoreceptive Function of the Ampullæ of Lorenzini

When the ampullæ of Lorenzini were first studied experimentally (see ref. 1), they were considered to be sensitive to mechanical stimuli like the other organs of the acoustico-lateralis system. But when Sand[2] recorded the electrical activity in their nerves, he found no response to mechanical stimuli but only to thermal stimuli; large, transient changes in impulse frequency occurred when the temperature was changed slightly. Ever since it has been widely accepted[3] that the function of the ampullæ is thermoreception, but this opinion has never been confirmed by behavioural experiment.

The possibility of mechanical sensitivity in the ampullary system of *Raia clavata* has now been re-investigated, using an electrical recording technique. A response to mechanical stimuli does in fact occur, but only to those stimuli which increase or reduce the pressure within the ampullæ themselves relative to the pressure outside (Fig. 1). The result of a sudden increase in pressure is an increase in the basic frequency, which then undergoes rapid and almost complete adaptation; the result of a sudden reduction in pressure is a decrease in frequency with a similar, rapid adaptation. In each case, when the pressure is returned to normal, there is an 'off' effect of opposite sign to the 'on' effect but equally rapid adaptation. The adaptation in other preparations is not so complete as it is in the case of Fig. 1. Part of what is shown here as adaptation is probably due to changes in pressure caused by mechanical accommodation of the tissues. Almost all single-fibre preparations (twenty-five out of twenty-seven) were mechanically sensitive in this way; they were also sensitive to temperature change.

The changes in pressure within the ampullæ were brought about in the apparatus shown in Fig. 2. The mandibular capsule of the ray was dissected out with its jelly-filled tubes and the strip of skin in which they ended; the preparation was held down on a flat plate by a partition which fitted closely around the tubes at the point at which they entered the capsule, so that movements of the skin did not cause movements of the capsule while pressure changes could be transmitted to the ampullæ through the tubes. The nerve trunk was cut down until the activity of only a single fibre was recorded, and therefore only a single ampulla and tube were involved. This method of mounting the preparation, though not necessary, was convenient in obtaining a response.

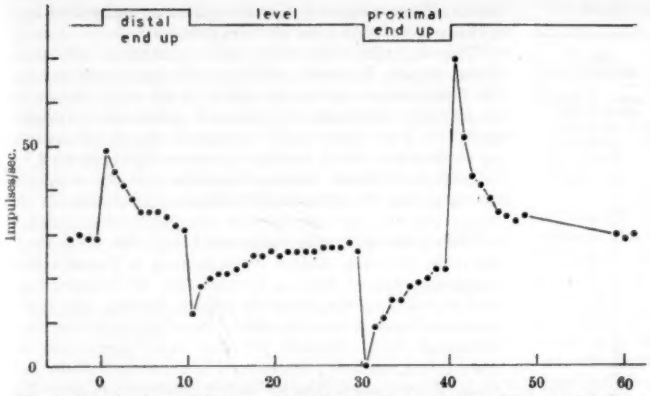

Fig. 1. Impulse frequencies in a single fibre from an ampulla of Lorenzini during stimulation by tilting. Lower trace, frequency; upper trace, stimulus

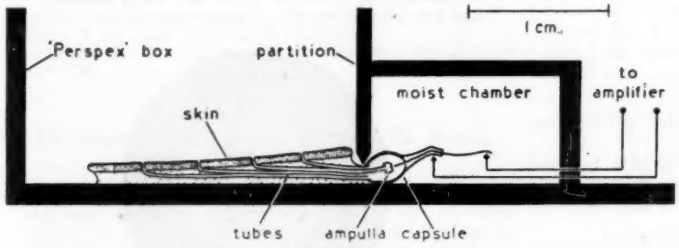

Fig. 2. The preparation mounted in the apparatus

The most effective stimulus was the insertion of a narrow probe into the opening of the tube; this resulted in a vigorous outburst of impulses. The pressure in the ampullæ could also be increased or reduced by pushing the distal end of the preparation towards, or pulling it away from, the capsule; a movement of 0·25 mm. towards caused a doubling of the basic frequency, and a movement of 0·25 mm. away caused total inhibition. A similar effect could be produced by tilting the whole preparation about an axis at right angles to the tubes. Raising the distal end increased the pressure in the ampullæ because part of the weight of the skin and connective tissues pressed down on the tubes where they were held by the partition; a 10° tilt in this way caused a doubling of frequency. When the preparation was tilted the other way the skin and tubes were pulled away from the partition, lowering the pressure in the ampullæ; a 10° tilt caused total inhibition. The effect of a blunt probe pressing on the skin varied according to its position; the frequency increased when the probe was directly above the tube and was therefore increasing the pressure in the ampulla; the discharge slowed down when the point of application was on another part of the skin, for in this case the distortion of the tissues must have resulted in a relative reduction of pressure within the ampulla. An indentation of the skin of 0·5 mm. caused a doubling of frequency; sensitivity of the same order was found in the pressure receptors in the margin of the fin (cf. ref. 4).

It has been suggested[3] that the ampullæ are depth receptors, sensitive to hydrostatic pressure. This kind of stimulus can easily be imitated in experiments, since it does not depend on a differential pressure between inside and outside the ampullæ. Pressure on the outside of the capsule wall has no effect on the impulse frequency, nor has sudden increase by one atmosphere or release of the pressure within an air-tight box containing the preparation. These results help to explain why the ampullæ have previously been reported as insensitive to mechanical stimulation.

It is therefore suggested that the ampullæ of Lorenzini have, after all, a mechanoreceptive function. It is not possible at the moment to determine which natural stimuli are the most important ones, but certainly contacts with solid objects on the sea bottom when swimming or burrowing would be effective stimuli. The ampullæ may also be sensitive enough to detect the local changes and patterns of water pressure over the surface of the body as the fish swims, especially as they are affected by the presence of near-by obstacles. The function of the ampullæ would therefore overlap on one hand that of the segmental cutaneous receptors, and on the other that of the lateral line. The morphological arrangement of the organs, with their tubes ending all over the dorsal and ventral surfaces and their sensitive ampullæ gathered into a few specialized, tough capsules with cranial innervation, makes possible a more rapid and accurate comparison of information from different parts of the body than would be possible by the cutaneous receptor system. Nevertheless, the ampullæ have a slower and less complete adaptation than the lateral-line organs, and would therefore be useful in detecting the slower and longer-lasting pressure stimuli. If this be so, the thermal sensitivity may, as in other excitable tissues[2,5], be an incidental effect, that is, a by-product of the mechanisms in the nerve endings responsible for the repetitive discharge.

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Amyloids of Plant Seeds

Using the staining of cell-walls blue by an iodine in potassium iodide solution (0·3 gm. iodine and 1·6 gm. potassium iodide dissolved in 100 ml. water[1]), many plant species previously designated as containing amyloid in their seeds[6] (for example, of the genera *Iris*, *Polygonatum*, *Narcissus*, *Hydrophyllum*) are excluded, while others show the amyloid reaction

Table 1. Amyloid-containing Genera and Species

Plant family	Genus	No. of positive species previously known	No. of species found	
			positive	negative
Acanthaceae	*Anisacanthus*	—	1	—
	Beloperone	—	2	—
	Peristrophe	—	1	2
	Schwabea	1	1	—
	Thunbergia	1	3	—
Anonaceae	15 genera	—	26	—
Balsaminaceae	*Impatiens*	1	1	7
Linaceae	*Linum*	1	3	*c.* 10
Melianthaceae	*Melianthus*	—	2	—
Myrsinaceae	*Ardisia*	1	5	—
	Maesa	—	5	—
	Myrsine	—	1	—
	Rapanea	—	2	—
Papilionaceae	*Goodia*	1	1	—
	Mucuna	1	1	4
Primulaceae	20 genera	3	30	—
Ranunculaceae	*Paeonia*	1	*c.* 20	—
Sapindaceae	*Cardiospermum*	—	2	—
Sapotaceae	*Achras*	—	1	—
	Dipholis	1	2	—
	Illipe	—	1	—
	Mimusops	1	3	—
	Omphalocarpum	—	2	—
	Siderozylon	1	3	—
Theophrastaceae	*Jacquinia*	—	1	—
Tropaeolaceae	*Tropaeolum*	1	4	—

with this reagent. The species of the latter group are summarized in Table 1.

By testing seeds of about 2,500 species I found that, besides the species already known to contain amyloid, a fair number of other species also show the reaction.

In the Caesalpiniaceae I found 85 amyloid-containing species (belonging to 42 different genera) and 98 amyloid-negative species (belonging to 61 genera). With two exceptions, all the positive species belong to the tribes Cynometreae and Amherstieae, which suggests that amyloid is a physiological characteristic for these tribes. In this connexion it is interesting that I found starch especially in the tribe Swartzieae, while it is known that galactomannan occurs frequently as a cell-wall constituent of the cotyledons in the tribes Cassieae and Eucaesalpinieae.

Roughly speaking, the chemical characteristics of the carbohydrate of the seed runs parallel to the morphological characteristics on which the classification of the Caesalpiniaceae is based.

In other plant families I found that amyloid occurs either universally or only occasionally (Table 1). The number of fifteen species (belonging to fourteen genera) which were previously known to contain amyloid in their seeds has now been extended to roughly 120 species in 80 genera; these do not include the Caesalpiniaceae.

Some amyloid-containing plant families are interrelated; for example, of the order Primulales, the seeds of all tested species of the three families (Primulaceae, Myrsinaceae and Theophrastaceae) contain amyloids.

Very little is known of the chemical constitution of the substances responsible for the amyloid reaction. Only in *Paeonia* and *Tropaeolum* were the sugars glucose, galactose and xylose demonstrated[2]; in *Tamarindus* these sugars appeared to be the only amyloid constituents[3].

Presuming that the blue-colouring substances were chemically interrelated, I investigated the amyloids from seeds of 36 plant species, belonging to 31 genera; all the plant families of Table 1 were represented in this number. On hydrolysis and paper chromatography of the products of hydrolysis it appeared that with all investigated species glucose, galactose and xylose were found as the only sugars.

The relation between the quantities of these three sugars, however, differs from species to species. In *Tamarindus indica* the relation between the molar quantities of glucose, xylose and galactose is roughly as 3 : 2 : 1 ¼, while in *Tropaeolum majus* it appears to be about 4 : 3 : 2, and in *Cyclamen* hybr. as 4 : 3 : 1.

In view of these results, it seems that the amyloids are a group of chemically related substances, in the same way as the starches or the galactomannans.

This conception is supported by the following: amyloid threads, drawn by injecting a *Tamarindus*-amyloid solution from a syringe into an ethanol bath and stretching the threads before drying, showed a characteristic X-ray diagram. Similar diagrams were obtained from threads of the other amyloids investigated, namely, *Hymenaea courbaril*, *Schotia latifolia*, *Tropaeolum majus* and *Cyclamen* hybr. The diagram of *Tamarindus indica* is reproduced in Fig. 1. (I am indebted to Dr. D. R. Kreger and Miss H. J. M. Poot for preparing the X-ray diagrams.)

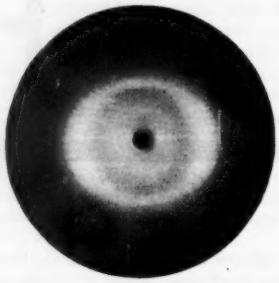

Fig. 1

In Anonaceae the cell-walls of the cotyledons are stained a brown-violet by iodine in potassium iodide solution. The colour produced by the isolated amyloid, however, is a bright red. From a qualitative observation, I gained the impression that in this 'amyloid' only a small quantity of xylose is present; perhaps this accounts for the aberrant colour with the reagent. Further investigation on the amyloid of Anonaceae will be published later.

Polarization microscope studies on sections from amyloid-containing seeds and on threads of amyloid showed that, just like cellulose, the positive birefringent amyloid chain molecules are deposited parallel to the cell-walls of *Tamarindus indica*, *Hymenaea courbaril*, *Tropaeolum majus* and *Cyclamen* hybr. I suggest this is general.

The function of amyloid in most seeds is without any doubt that of a reserve carbohydrate. Frank[5] found that the thickenings of the cell-walls of the cotyledons of *Tropaeolum majus* disappeared during germination, from which he concluded that amyloid was utilized by the embryo. I have been able to corroborate this. Moreover, the press-juice of cotyledons of germinated *Tropaeolum* seeds appeared to be able to liquefy a viscous amyloid solution, after which mono- and oligo-saccharides were formed.

Presumably the same holds for other amyloid-containing species, especially the amyloid-containing Caesalpiniaceae, which are a very rich source of amyloid. However, other species, for example, *Linum usitatissimum*, have such a low amyloid-content that its usefulness as a carbon reserve in the embryo is dubious.

During germination of *Tropaeolum* seeds starch grains appear in the cells of the cotyledons. It is uncertain whether this arises from the slowly disappearing amyloid, or from the oil in the cells. A remarkable fact is that in unripe seeds the cell-walls do not show the amyloid reaction, whereas the cells contain much starch. Only in the very last phase of ripening does amyloid appear while the starch disappears wholly. Therefore it is likely that amyloid in *Tropaeolum* is stable only during the resting period of the seed.

Details of these investigations will be published elsewhere.

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Differential Insecticide Damage in Maize Varieties

A MIXTURE of three parts of ethylene dichloride and one part of carbon disulphide (by volume) applied at the rate of 0·6 c.c./litre of storage space by pouring the liquid on to the surface has been effective for some years in preventing insect damage to maize grain (var. Tsolo) stored in closed bins for subsequent sowing. In 1956 the variety Mexican Elite was grown instead of Tsolo, and the grain after storage was found to have a very low germination capacity. A series of experiments was carried out to test the hypothesis that the insecticide was affecting the grain adversely, and that some varieties of maize were more susceptible than others to this treatment.

Grain of each of four varieties of maize was divided into two portions, one being kept as control and the other given the normal insecticidal treatment. Ten days later, seventy-eight grains from each of the treated and untreated samples of each variety were planted in garden soil under conditions suitable for germination. After seven days the number of plants that had germinated was determined by counting the number of shoots that had emerged. These results are summarized in Table 1.

Many of the emergent seedlings from the treated grain were distorted, and in order to obtain a measure of this distortion and the resultant stunting of the shoots, all seedlings were harvested at the first node and weighed on the eighth day after sowing. The results are summarized in Table 2.

It can be seen from the tables that in every instance treatment of the grain resulted in an increase in the number of plants that failed to emerge, and that response to the treatment differed from variety to variety both in this respect and also in the degree of stunting suffered by the seedlings that did emerge. Further, the suppression of germination and the stunting of growth are not necessarily parallel. On one hand, in Abakaliki Red the germination was strongly suppressed, but the majority of seedlings from the treated grain showed normal growth. On the other hand, in Trinidad, the treatment did not markedly affect germination but caused severe stunting.

Table 1. PERCENTAGE GERMINATION OF TREATED AND UNTREATED GRAIN, SEVEN DAYS AFTER SOWING

Variety	Untreated	Treated
Lagos White	97	90
Abakaliki Red	99	77
Mexican × Sie	91	71
Trinidad	97	86

Table 2. MEAN FRESH WEIGHT OF SHOOTS (IN GM.) ON EIGHTH DAY FROM SOWING

Variety	Untreated		Treated		S.E. of diff.	P (per cent)
	m	δ^2	m	δ^2		
Lagos White	2·15	0·48	1·76	1·06	0·15	1
Abakaliki Red	2·05	0·42	1·85	0·50	0·12	5–10
Mexican × Sie	1·78	0·31	1·04	0·31	0·09	< 0·1
Trinidad	1·62	0·26	0·27	0·05	0·06	< 0·1

It would seem desirable that the effect of the above insecticidal mixture on the viability of maize grain should be determined before this method of protection is employed for seed corn.

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Lungworm from Rats captured in Britain

DURING the period December 1954–April 1956, the lungs of a total of 191 wild rats from Cambridge, Cardiff, Liverpool, London, Nottingham, St. Albans and Wolverhampton were examined for lungworms. They included 24 *Rattus rattus* L. and 167 *Rattus norvegicus* Erkl. It was only possible to examine fresh lungs of nine *Rattus rattus* from London. The remaining lungs were collected by staff of the Infestation Control Division of the Ministry of Agriculture, Fisheries and Food. They were preserved in 10 per cent formalin and examined later. None of these rat lungs was infested with *Angiostrongylus cantonensis* (Chen., 1935), and in no case did the lung tissue appear to be abnormal pathologically.

Table 1 shows the number of rats examined from each location. The *Rattus rattus* were collected from British ports.

Table 1

Locality	*Rattus norvegicus*	*Rattus rattus*	Total
Cambridge	51	—	51
Cardiff	35	5	40
Liverpool	2	10	12
London	—	9	9
Nottingham	58	—	58
St. Albans	4	—	4
Wolverhampton	17	—	17
Total	167	24	191

In examining several hundreds of wild rats from England over a number of years, Mr. F. R. N. Pester, London School of Hygiene and Tropical Medicine, has not observed any lungworm infestations (personal communication).

In the present survey, although the results from the examination of such a small number of rat's

lungs cannot be regarded as being conclusive, it is indicated that *Angiostrongylus cantonensis* is probably an Oriental form which has spread southwards and become established in both the wild rats *Rattus norvegicus* and *Rattus rattus* in eastern Australia.

I wish to thank the staff of the Infestation Control Division of the Ministry of Agriculture, Fisheries and Food for co-operation in the collection of rat's lungs for examination; also Mr. F. R. N. Pester for his discussion on his previous observations.

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* On study leave from the University of Queensland and the Queensland Institute of Medical Research, Brisbane.

The African Freshwater Jellyfish *Limnocnida tanganyicae*

The freshwater medusa *Limnocnida tanganyicae* has been known for more than seventy years from the lakes of East, West and Central Africa. Until very recently, no evidence had been found for the existence of a hydroid stage, and it was generally considered that development must proceed from the egg through some larval form direct back to the medusa, which can also reproduce asexually by budding.

In 1954, Bouillon[1] discovered the hydroids attached to the stems of reeds in Lakes Tanganyika and Mohasi, and observed their development from fixed elongated larvæ. He also followed the development of medusæ by budding from the hydroids. The events between the laying of the eggs and the fixation of the larvæ, however, had not been observed; in fact, it was not known whether or not a free-swimming planula larva is produced.

On September 22 at about 6 p.m., we were lucky enough to sail into a swarm of sexually mature medusæ off Kazi on Lake Victoria. They were swimming close to the reeds on the lee side of an island in dead-calm water. Both eggs and sperms were shed in dishes in the laboratory, and we were able to observe cleavage as well as development and subsequent fixation of the free-swimming larvæ, and thus to complete our knowledge of the main events in the life-history.

Active sperms were seen among the eggs, which were about 90μ in diameter, and 2- and 4-cell stages appeared during the first four hours. After 16 hr. spherical morulæ 90–110μ in diameter were developed with a few long cilia insufficient for propulsion. In 28 hr. many of these had, without increase in size but with further cell division, become spherical free-swimming larvæ propelled by a large number of cilia. Some of these had just begun to elongate. After 42 hr. many had settled on the bottom and sides of the dish and in 60 hr. all were fixed, were elongated and had lost their cilia. The approximate dimensions of this stage were 130μ × 50μ. Hydroids were first seen after five days. These were flask-shaped, without tentacles, about 150μ long and 70μ in maximum diameter.

The temperature of the laboratory was 20–23° C.

L. C. Beadle
I. F. Thomas

Department of Zoology,
Makerere University College,
Kampala, Uganda.
Oct. 25.

[1] Bouillon, J., *Bull. Acad. Roy. Sci. Colon.*, Tome 1, fasc. 2, 229 (1955).

Rabbits in Africa

A statement on the distribution of the common rabbit, *Oryctolagus cuniculus* L., in "The Rabbit", by H. V. Thompson and A. N. Worden[1] (see p. 59 of this issue), calls for comment and correction. On pp. 4–5 it is reported that the rabbit is able "even to live successfully in Central Africa within two degrees of the Equator". On p. 16 this is amplified by a reference to the late Prof. Hale Carpenter's claim[2] to have found a well-established colony of European rabbits at Masindi, Uganda. On p. 17 the distribution map shows Masindi as the only locality in tropical Africa for the common rabbit. Although the origin of the colony was said to be unknown, and the local natives gave the animals the same name as the indigenous hare of the genus *Lepus*, Hale Carpenter suggested that these animals were descendants of European rabbits said to have been imported and released in 1881 by Emin Pasha, then governor of Equatoria Province, Sudan. It seems that the identification of the animals as European rabbits was not based upon critical examination of specimens. I am not aware of any other report of European rabbits in tropical Africa, and the following facts indicate that Hale Carpenter's record should be removed from the literature on the common rabbit.

In 1928 Capt. C. R. S. Pitman, then game warden of Uganda, collected a series of rabbit-like animals at Masindi. He described them as being abundant along grassy roads at night. The specimens formed the basis of the description by J. St. Leger[3] of a new lagomorph under the name *Lepus marjorita*. The characters of skin and skull separated it clearly from other hares and rabbits. Later, St. Leger[4] raised the new species to generic rank, *Poelagus*, on the basis of skeletal characters. Later, St. Leger[5] reported another race of *P. marjorita* from south-west Sudan, near the Belgian Congo border, and Hatt[6] has recorded it from north-east Belgian Congo on the evidence of specimens collected in 1912. Superficially there is a resemblance to the European rabbit; but closer examination shows that its characters are perfectly distinct.

In view of these facts, it seems that Hale Carpenter's report of European rabbits in Uganda was based on a misidentification of *Poelagus marjorita*, and this misleading claim should now be rejected.

R. W. Hayman

Dept. of Zoology,
British Museum (Natural History),
London, S.W.7.
Oct. 24.

[1] Thompson, H. V., and Worden, A. N., "The Rabbit", New Naturalist Series (1956).
[2] Hale Carpenter, G. D. H., *Nature*, **116**, 677 (1925).
[3] St. Leger, J., *Ann. Mag. Nat. Hist.*, **4**, 292 (1929).
[4] St. Leger, J., *Proc. Zool. Soc. Lond.*, **1**, 119 (1932).
[5] St. Leger, J., *Ann. Mag. Nat. Hist.*, **16**, 598 (1935).
[6] Hatt, R. T., *Bull. Amer. Mus. Nat. Hist.*, **76**, 555 (1940).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 14

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. Bronowski: "The Choice of Inductions".

Tuesday, January 15

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. A. J. Ayer: "Some Aspects of Existentialist Philosophy".*

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Is There a Future for the Diesel Engine in Combination with the Gas Turbine?"

Wednesday, January 16

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), from 2.30 p.m. to 7 p.m.—Discussion meeting on "New Methods in the Ozone Problem".

PHYSICAL SOCIETY, COLOUR GROUP (in the theatre of the Strand Electrical and Engineering Co., Ltd., 29 King Street, London, W.C.2), at 3.30 p.m.—Mr. R. Blore: "Colour in Theatrical Make-up".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. R. Black, Dr. R. R. E. Jacobson and Mr. W. N. MacLeod: "Ring-complexes in the Younger Granite Province of Northern Nigeria".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Miss K. Gales and Prof. M. G. Kendall: "An Inquiry Concerning Interviewer Variability".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mrs. Barbara Simonds: "Twin Research in Tuberculosis".*

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Annual General Meeting. Mr. J. Smiles: "Fluorescence Microscopy" (Presidential Address).

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, at King's College, Strand, London, W.C.2), at 6.30 p.m.—Prof. H. J. Emeléus, F.R.S.: "The Chemistry of the Newer Elements".

Thursday, January 17

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. N. M. Aires: "Operations at the Ethel Asbestos Mine, Southern Rhodesia"; Mr. W. E. Sinclair: "The Kilphuis Crocidolite Deposits"; Mr. B. W. H. Harding: "Prospect Sampling by Air-Flush Drill".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. P. Erdös: "Some Old and New Problems in the Distribution of Primes".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. A. Cameron Brown and Mr. A. W. Gray: "Electricity in Modern Commercial Horticulture".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. E. G. T. Liddell: "Cajal and Sherrington".*

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. T. D. Robson: "Refractory Concrete".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Symposium on "Toxoplasmosis".

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (at 32 Welbeck Street, London, W.1), at 8 p.m.—Ordinary meeting, followed by papers on "Aspects of Radiation Damage likely to be involved in Tumour Regression".

Friday, January 18

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 4 p.m.—Prof. A. Haddow: "Modern Views of Carcinogenesis".*

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion—"The Dating of Rocks". Chairman: Prof. C. E. Tilley, F.R.S.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. P. A. Hearne: "The All-Weather Operation of Transport Helicopters".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Captain W. R. Colbeck: "The Salvaging of Ships with particular reference to the *Empress of Canada*" (Thomas Lowe Gray Lecture).

INSTITUTE OF PHYSICS, NON-DESTRUCTIVE TESTING GROUP (at 47 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. E. E. Smith: "Radiological Protection—the Present View".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 7 p.m.—Mr. O. S. Puckle: "Electronic Automation of Machine Tools".

Saturday, January 19

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, London Hospital Medical College, Turner Street, London, E.1), at 11 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BIOCHEMIST, Senior Grade (B.Sc. and/or A.R.I.C. and wide general experience in medical biochemistry), for developing service in the Area Laboratory—The Group Secretary, Coventry and Warwickshire Hospital, Stoney Stanton Road, Coventry (January 19).

SENIOR PSYCHOLOGIST—The Secretary, Oakwood Hospital, Maidstone, Kent (January 21).

PRINCIPAL OF THURROCK TECHNICAL COLLEGE, Grays—The Chief Education Officer, County Offices, Chelmsford, Essex (January 25).

SENIOR BIOCHEMIST (science (honours) graduate), for research work in the Geriatric Unit, Sunderland General Hospital—The Senior Administrative Medical Officer, Regional Hospital Board, Benfield Road, Newcastle-upon-Tyne 6 (January 26).

ASSISTANT (registered medical practitioner or science graduate with a scientific training in physiology) IN THE PHYSIOLOGY DEPARTMENT—The Secretary and Bursar, University College, Dublin (January 31).

BRITISH COKE RESEARCH ASSOCIATION FELLOW (honours graduate in chemistry, physics, or applied science relating to fuel technology), to work on the physical chemistry of carbon under the direction of the Professor of Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (January 31).

RESEARCH ASSISTANT (with an honours degree in mathematics or in pure or applied science) IN ELECTRONIC COMPUTING—The Registrar, The University, Leeds 2 (January 31).

LECTURER IN CHEMICAL ENGINEERING; and a LECTURER (with special qualifications in physical chemistry) IN CHEMISTRY, at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, February 2).

LECTURER (with a good university degree or equivalent qualifications, and experienced in the teaching of technical subjects) IN EDUCATION—The Registrar, The University, Manchester 13 (February 8).

SPECIAL LECTURER (with good academic qualifications and some years experience in secondary school teaching) IN EDUCATION—The Registrar, The University, Manchester 13 (February 9).

LECTURER IN ZOOLOGY—The Secretary, The Queen's University, Belfast (February 15).

LECTURER (with an honours degree in botany or agricultural botany, and preferably with special interests or research experience in economic botany, or the taxonomy of economic plants) IN AGRICULTURAL BOTANY—The Registrar (Room 9 O.R.B.), The University, Reading (February 15).

PLANT PHYSIOLOGIST (with research experience, preferably, but not essentially, in the fields of carbohydrate metabolism, mineral nutrition or plant growth regulators); and a PLANT BREEDER AND GENETICIST (with research experience), at the Waite Agricultural Research Institute (University of Adelaide), to undertake research related to a general programme for the improvement of barley—The Registrar, University of Adelaide, Adelaide, South Australia (February 15).

PROFESSOR OF ZOOLOGY—The Secretary and Bursar, University College, Dublin (February 16).

LECTURER IN PURE MATHEMATICS—The Secretary, The Queen's University, Belfast (February 20).

CHAIR OF CIVIL ENGINEERING at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 22).

ASSISTANT CURATOR IN THE DEPARTMENT OF PATHOLOGY, University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

J. R. MCKENZIE CANCER RESEARCH FELLOW, to carry out research in cancer at the Medical School, University of Otago, Dunedin, New Zealand, under the supervision of Dr. F. Bielschowsky (Director of Cancer Research)—The General Secretary, British Empire Cancer Campaign, 11 Grosvenor Crescent, Hyde Park Corner, London, S.W.1 (New Zealand, March 15).

RESEARCH FELLOWS for independent research—The Registrar (Room 9 O.R.B.), The University, Reading (March 18).

ASSISTANT BIOCHEMIST (young graduate with a good honours degree in chemistry or equivalent qualification, and preferably some analytical experience) IN THE DEPARTMENT OF PATHOLOGY, for duties which include participation in research, particularly in the field of steroids, under the direction of the Head of the Department—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

ASSISTANT EXPERIMENTAL OFFICERS (with G.C.E. in five subjects with two advanced level passes in mathematical or scientific subjects (including physics), and English language at ordinary level), for work connected with a 6-MeV. Van de Graaff accelerator including production, inspection and detailed analysis of spectrographic records of charged particle reactions—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1366/34.

ASSISTANT, Grade B (graduate and capable of undertaking work of diploma and degree standard), IN THE DEPARTMENT OF PHYSICS AND MATHEMATICS, to teach physics in first instance to G.C.E. "A"—The Principal, West Ham College of Technology, Romford Road, Stratford, London, E.15.

ASSISTANT, Grade B, TO TEACH MATHEMATICS at Peterborough Technical College—The Chief Education Officer, Education Offices, Town Hall, Peterborough.

ASSISTANT LIBRARIAN (university graduate) for duties in the Science Libraries—The Registrar, The University, Liverpool.

ASSISTANT PROFESSOR (with an honours degree in mathematics and preferably some postgraduate experience in research or teaching) IN THE DEPARTMENT OF MATHEMATICS—The Head of the Department of Mathematics, University of New Brunswick, Fredericton, N.B., Canada.

BACTERIOLOGICAL ASSISTANT (female, preferably with a degree including bacteriology as a special subject, or postgraduate bacteriological experience) IN THE CENTRAL ENTERIC REFERENCE LABORATORY, for work concerned with bacteriophage typing and bacteriophage research—The Director, Central Enteric Reference Laboratory, Central Public Health Laboratory, Colindale Avenue, London, N.W.9.

BIOCHEMICAL TECHNICIANS (student and junior)—The Chief Technician, Imperial Cancer Research Fund, Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2, marking envelope "Technicians".

BIOCHEMIST IN THE ENDOCRINOLOGY LABORATORY, to assist in clinical research—The House Governor, Royal Marsden Hospital, Fulham Road, London, S.W.3.

CURATOR (with Ph.D. or equivalent and specialized training in palæontology) OF GEOLOGY, for duties which will include the classification and organization of university collections of fossils, rocks and minerals, with an additional light teaching load and responsibility to carry out research work—The Chairman, Department of Geology, Hamilton College, McMaster University, Hamilton, Canada.

DIRECTOR OF RESEARCH—The Chairman of the Council, Printing, Packaging and Allied Trades Research Association, Randalls Road, Leatherhead, Surrey.

GEOPHYSICIST (or PHYSICIST), and GEOLOGISTS (4), for groundwater studies; a SEDIMENTATIONIST or STRATIGRAPHER (M.Sc. or Ph.D.), to do research on the Alberta Tar Sands; and a GEOLOGIST (Ph.D.) to join the Council's Petroleum Geochemistry Section—The Secretary, Research Council of Alberta, 87th Avenue and 114th Street, Edmonton, Alberta, Canada.

HOSPITAL PHYSICS TECHNICIAN (preferably with a knowledge of workshop practice), to assist in the following work: calibration and maintenance of X-ray apparatus, making physics equipment, and carrying out measurements on radioactive isotopes—The Hospital Secretary, Leicester Royal Infirmary, Leicester.

JUNIOR TECHNICIAN for research work in the Medical Unit, mainly in hæmatology, The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

LECTURERS and RESEARCH FELLOWS IN THE INSTRUMENT TECHNOLOGY SECTION, PHYSICS DEPARTMENT—The Professor of Instrument Technology, Imperial College, London, S.W.7.

MECHANICAL ENGINEERS or MATHEMATICIANS (with a first- or second-class honours degree in engineering or mathematics or equivalent qualifications), to carry out research and development work in the fields of applied mechanics, stress analysis and vibrations—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 1354/34.

METALLURGIST or PHYSICIST (preferably with experience of electron microscopy or X-ray crystallography in connexion with metals), for research on age-hardening phenomena in aluminium alloys—Dr. M. S. Fisher, Metallurgy Department, Imperial College, London, S.W.7.

SENIOR LECTURER (with good academic and professional qualifications, and industrial experience in electrical power supply with special reference to system protection) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING AND PHYSICS—The Clerk to the Governing Body, Borough Polytechnic, Borough Road, London, S.E.1.

SENIOR PHYSICIST (with a degree in physics and preferably some experience in nuclear development) on the Chief Engineer's Headquarters staff, to assist in all matters relating to the Board's Nuclear Power Station programme—The Secretary, South of Scotland Electricity Board, P.O. Box 178, 351 Sauchiehall Street, Glasgow, C.2.

SENIOR TECHNICIAN (preferably with experience of histological and museum techniques) IN THE ZOOLOGY DEPARTMENT; and a TECHNICIAN IN THE CHEMISTRY DEPARTMENT—The Secretary, Royal Holloway College, Englefield Green, Surrey.

TECHNICIAN (preferably with some biochemical experience) IN THE EXPERIMENTAL PSYCHOLOGICAL LABORATORY—The Secretary, University College, Gower Street, London, W.C.1, quoting "Psychology/2".

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Aero Research Technical Notes. Bulletin No. 165: The Structure of the Comet. Pp. 4. (Duxford: Aero Research Limited, 1956.) [1211

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 1—(No. 7): Feeding and Reproduction in the Limapontiidae. By Dr. Thomas Gascoigne. Pp. 129–152+2 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 10s. 6d. [1211

British Rayon Research Association. 9th Annual Report, October 1956; Report of the Director of Research for 1955–56. Pp. 6. (Manchester: British Rayon Research Association, 1956.) [1211

British Museum (Natural History). Fossil Mammals of Africa No. 11: Erinaceidae from the Miocene of East Africa. By P. M. Butler. Pp. iii+75+4 plates. (London: British Museum (Natural History), 1956.) 40s. [1211

British Council. Annual Report, 1955–1956. Pp. vi+94+6 plates. (London: British Council, 1956.) [1411

Aeronautical History in Pictures. Pp. 32 (65 illustrations). (London: H.M. Stationery Office, 1956. Published for the Science Museum.) 2s. net. [1411

Department of Scientific and Industrial Research. Scientific Research in British Universities, 1955–56. Pp. vii+372. (London: H.M. Stationery Office, 1956.) 21s. net. [1411

Anti-Locust Bulletin 24: Pigmentation of Hoppers of the Desert Locust (*Schistocerca gregaria* Forskål.) in relation to Phase Coloration. By Dr. B. Nickerson. Pp. ii+34. (London: Anti-Locust Research Centre, 1956.) 4s. [1511

Tube Investments Limited. Chairman's Statement, Annual General Meeting, 10th December, 1956. Pp. 11. (London: Tube Investments Limited, 1956.) [1511

Author's Alterations Cost Money and Cause Delay. Pp. 10. (London: British Federation of Master Printers, 1956.) 6d. [2011

National Institute of Agricultural Botany. Farmers' Leaflet No. 3 (September, 1956): Varieties of Potatoes. Pp. 6. (Cambridge: National Institute of Agricultural Botany, 1956.) [2011

Other Countries

Commonwealth of Australia: Department of External Affairs, Australian National Antarctic Research Expeditions—Interim Reports. No. 10: Hourly Measurements of Ionospheric Characteristics, Macquarie Island, 1953. By A. S. Little. Pp. 148. No. 12: Hourly Measurements of Ionospheric Characteristics, Macquarie Island, 1954. By T. F. Firmstone. Pp. 65. No. 13: Hourly Measurements of Ionospheric Characteristics, Macquarie Island, 1955. By D. R. L. Callow. Pp. 60. (Melbourne: Antarctic Division, Department of External Affairs, 1956.) [811

Meddelande från Gullåkers Växtförädlingsanstalt, Hammenhög. Nr. 12: Studies on Seed-Setting and Seed Yield in Oil Flax. By Rolf Manner. Pp. 139. (Hammenhög: Gullåkers Växtförädlingsanstalt, 1956.) [1211

United States Naval Observatory. Circular No. 69: Positions, Areas, and Counts of Sunspots, April 1956. By Winifred Sawtell Cameron. Pp. 7. (Washington, D.C.: United States Naval Observatory, 1956.) [1211

British Honduras. Annual Report of the Forest Department for the year 1955. Pp. ii+29. (Belize: Conservator of Forests, 1956.) [1211

Trigonometric Series—a Survey. By Prof. R. L. Jeffery. Pp. iv+39. (Canadian Mathematical Congress Lecture Series, No. 2.) (Toronto: University of Toronto Press; London: Oxford University Press, 1956.) 20s. net. [1511

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique No. 50: Le Travail de la Scie Circulaire Application au Sciage du Diambi (*Guarea cedrata*). Par L. Laloyaux. Pp. 48+8 photos. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1956.) 40 francs. [1511

Smithsonian Miscellaneous Collections. Vol. 134, No. 2: The Asiatic Species of Birds of the Genus *Criniger* (Pycnonotidæ). By H. G. Deignan. (Publication 4266.) Pp. 9. (Washington, D.C.: Smithsonian Institution, 1956.) [1511

Chicago Natural History Museum. The King's Day: a Day in the Life of an African King. By Margaret Plass. Pp. 22+9 plates. (Chicago: Chicago Natural History Museum, 1956.) 35 cents. [1511

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 283: Courageous-Matthews Lakes Area, District of Mackenzie, Northwest Territories. By J. C. G. Moore. Pp. vii+52+4 plates+2 maps. (Ottawa: Queen's Printer, 1956.) 75 cents. [1511

United States Department of the Interior: Geological Survey. Bulletin 1016: The Wishbone Hill District, Matanuska Coal Field, Alaska. By Farrell F. Barnes and Thomas G. Payne. Pp. vi+88+20 plates. 2.50 dollars. Bulletin 1023: Bentonite Deposits in Marine Cretaceous Formations, Hardin District, Montana and Wyoming. By Maxwell M. Knechtel and Sam H. Patterson. With a section on Laboratory Procedures used for Testing the Bentonites by Sam H. Patterson. Pp. v+116+2 plates. n.p. Bulletin 1027-O: Thorium and Rare-Earth Minerals in Powderhorn District, Gunnison County, Colorado. By J. C. Olson and S. R. Wallace. Pp. iv+693–722+plates 55 and 56. 60 cents. Bulletin 1042-A: Geology of the Johnson Creek Quadrangle, Caribou County, Idaho. By R. A. Gulbrandsen, K. P. McLaughlin, F. S. Honkala, and S. E. Clabaugh. Pp. iii+24+2 plates. 75 cents. Bulletin 1042-B: Airborne and Ground Reconnaissance of Part of the Syenite Complex near Wausau, Wisconsin. By R. C. Vickers. Pp. iii+25–44. 15 cents. Bulletin 1042-E: Pyrite Deposits at Horseshoe Island, Alaska. By Francis A. Stejer. Pp. iii+107–122+plate 12. 45 cents. Bulletin 1027-J: Geology of the Stanford-Hobson Area, Central Montana. By James D. Vine. Pp. iv+405–470+plates 45–47. 1.25 dollars. Bulletin 1027-M: Reconnaissance Geology of Western Mineral County, Montana. By Robert E. Wallace and John W. Hosterman. Pp. iv+575–612+plates 48–51. 1.25 dollars. (Washington, D.C.: Government Printing Office, 1956.) [1511

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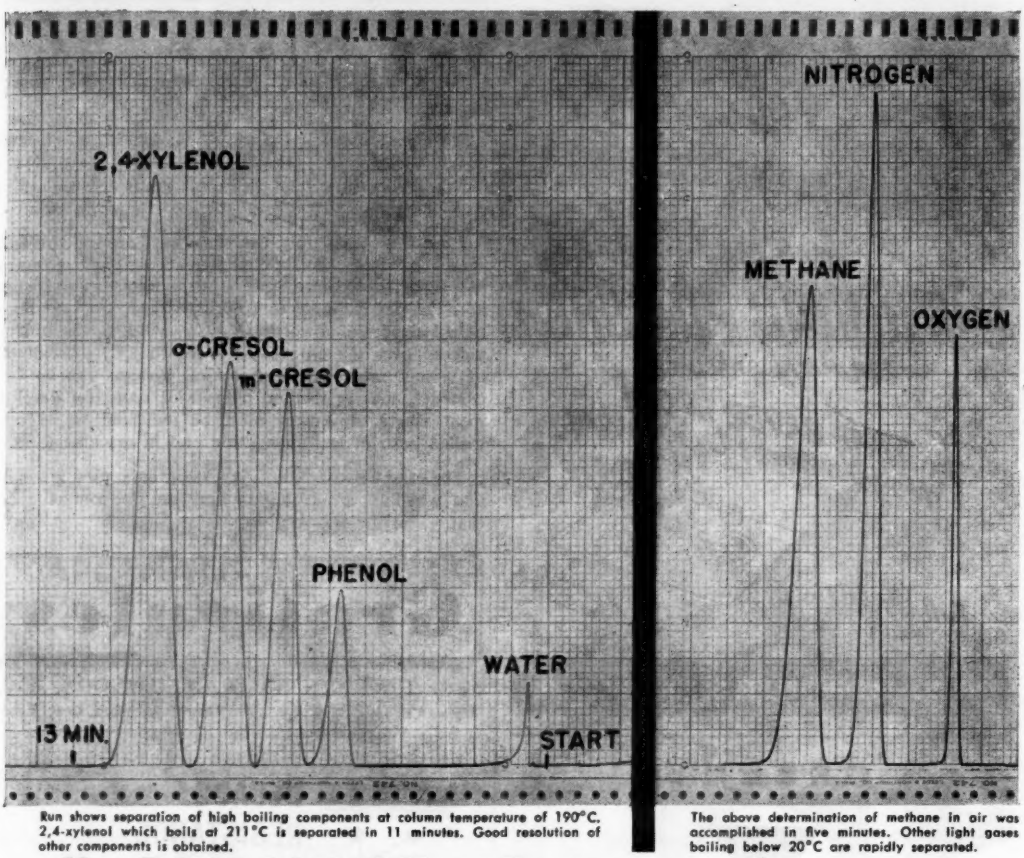

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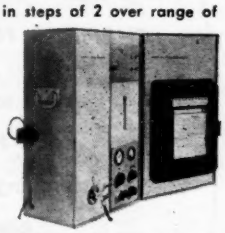

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